DEPARTMENT OF ENVIRONMENT & CONSERVATION

DOE OVERSIGHT DIVISION

ENVIRONMENTAL MONITORING PLAN

JANUARY through DECEMBER 2006

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This plan was published
With 100% Federal Funds
DE-FG05-96OR22520
DE-FG05-96OR22521

Tennessee Department of Environment and Conservation, Authorization No. 327023, 45 copies. This public document was promulgated at a cost of $3.27 per copy. December 2005.

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LIST OF COMMON ACRONYMS AND ABBREVIATIONS

ASER	Annual Site Environmental Report (written by DOE)
ASTM	American Society for Testing and Materials
BCK	Bear Creek Kilometer (station location)
BFK	Brushy Fork Creek Kilometer (station location)
BJC	Bechtel Jacobs Company
BMAP	Biological Monitoring and Abatement Program
BNFL	British Nuclear Fuels Limited
BOD	Biological Oxygen Demand
BWXT	Y-12 Prime Contractor (current)
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CAP	Citizens Advisory Panel (of LOC)
CCR	Consumer Confidence Report
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
COC	Contaminants of Concern
COD	Chemical Oxygen Demand
CPM (cpm)	Counts per Minute
CRM	Clinch River Mile
CROET	Community Reuse Organization of East Tennessee
CWA	Clean Water Act
CYRTF	Coal Yard Runoff Treatment Facility (at ORNL)
D&D	Decontamination and Decommissioning
DOE	Department of Energy
DOE-O	Department of Energy-Oversight Division (TDEC)
DWS	Division of Water Supply (TDEC)
E. coli	Escherichia coli
EAC	Environmental Assistance Center (TDEC)
ED1, ED2, ED3	Economic Development Parcel 1, Parcel 2, and Parcel 3
EFPC	East Fork Poplar Creek
EMC	Environmental Monitoring and Compliance (DOE-O Program)
EMWMF	Environmental Management Waste Management Facility
EPA	Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, Trichoptera (May flies, Stone flies, Caddis flies)
ERAMS	Environmental Radiation Ambient Monitoring System
ET&I	Equipment Test and Inspection
ETTP	East Tennessee Technology Park
FDA	U.S. Food and Drug Administration
FRMAC	Federal Radiation Monitoring and Assessment Center
g	Gram
GHK	Gum Hollow Branch Kilometer (station location)
GIS	Geographic Information Systems
GPS	Global Positioning System
GW	Ground Water
GWQC	Ground Water Quality Criteria
HAP	Hazardous Air Pollutant
HCK	Hinds Creek Kilometer (station location)
IBI	Index of Biotic Integrity
IC	In Compliance
"ISCO" Sampler	Automatic Water Sampler
IWQP	Integrated Water Quality Program
K-####	Facility at K-25 (ETTP)

LIST OF COMMON ACRONYMS AND ABBREVIATIONS CONTINUED

K-25	Oak Ridge Gaseous Diffusion Plant (now called ETTP)
KBL	Knoxville Branch Laboratory
KEAC	Knoxville Environmental Field Office
l	Liter
LC_{50}	Lethal Concentration at which 50 % of Test Organisms Die
LMES	Lockheed Martin Energy Systems (past DOE Contractor)
LOC	Local Oversight Committee
LWBR	Lower Watts Bar Reservoir
MARSSIM	Multi-agency Radiation Survey and Site Investigation Manual
MBK	Mill Branch Kilometer (station location)
MCL	Maximum Contaminant Level (for drinking water)
MDC	Minimum Detectable Concentration
MEK	Melton Branch Kilometer (station location)
µg	Microgram
mg	Milligram
MIK	Mitchell Branch Kilometer (station location)
ml	Milliliter
MMES	Martin Marietta Energy Systems (past DOE Contractor)
µmho	Micro mho (mho=1/ohm)
MOU	Memorandum of Understanding
mR	Microroentgen
mrem	1/1000 of a rem – millirem
N, S, E, W	North, South, East, West
NAAQS	National Ambient Air Quality Standards
NAREL	National Air and Radiation Environmental Laboratory
NAT	No Acute Toxicity
NEPA	National Environmental Policy Act
NIC	Not In Compliance
NOAEC	No Observable Adverse Effect Concentration (to Tested Organisms)
NOV	Notice of Violation
NPDES	National Pollution Discharge Elimination System
NRWTF	Non-Radiological Waste Treatment Facility (at ORNL)
NT	Northern Tributary of Bear Creek in Bear Creek Valley
OMI	Operations Management International (runs utilities at ETTP under CROET)
OREIS	Oak Ridge Environmental Information System http://www-oreis.bechteljacobs.org/oreis/help/oreishome.html
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OSHA	Occupational Safety and Health Association
OSL	Optically Stimulated Luminescent (Dosimeter)
OU	Operable Unit
PACE	Paper, Allied-Industrial, Chemical, and Energy Workers Union
PAM	Perimeter Air Monitor
PCB	Polychlorinated Biphenol
pCi	$1x10^{-12}$ Curie (Picocurie)
PCM	Poplar Creek Mile (station location)
pH	Proportion of Hydrogen Ions (acid vs. base)
PWSID	Potable Water Identification “number”
ppb	Parts per Billion

LIST OF COMMON ACRONYMS AND ABBREVIATIONS CONTINUED

ppm	Parts per Million
ppt	Parts per Trillion
PRG	Preliminary Remediation Goals
QA	Quality Assurance
QC	Quality Control
R	Roentgen
RBP	Rapid Bioassessment Program
RCRA	Resource Conservation and Recovery Act
REM (rem)	Roentgen Equivalent Man (unit)
RER	Remediation Effectiveness Report
ROD	Record of Decision
RSE	Remedial Site Evaluation
SLF	Sanitary Landfill
SNS	Spallation Neutron Source
SOP	Standard Operating Procedure
SPOT	Sample Planning and Oversight Team (TDEC)
SS	Surface Spring
STP	Sewage Treatment Plant
SW	Surface Water
TDEC	Tennessee Department of Environment and Conservation
TDS	Total Dissolved Solids
TIE	Toxicity Identification Evaluation
TLD	Thermoluminescent Dosimeter
TOA	Tennessee Oversight Agreement
TRE	Toxicity Reduction Evaluation
TRM	Tennessee River Mile
TRU	Transuranic
TSCA	Toxic Substance Control Act
TSCAI	Toxic Substance Control Act Incinerator
TSS	Total Suspended Solids
TTHM's	Total Trihalomethanes
TVA	Tennessee Valley Authority
TWQC	Tennessee Water Quality Criteria
TWRA	Tennessee Wildlife Resources Agency
U.S.	United States
UT-Battelle	University of Tennessee-Battelle (ORNL Prime Contractor)
VOC	Volatile Organic Compound
WCK	White Oak Creek Kilometer (station location)
WM	Waste Management
WOL	White Oak Lake
X-####	Facility at X-10 (ORNL)
X-10	Oak Ridge National Laboratory
Y-####	Facility at Y-12
Y-12	Y-12 Plant (Area Office)

Introduction

The Tennessee Department of Environment and Conservation, DOE Oversight Division (the division) under terms of the Tennessee Oversight Agreement Section A.7.2.1 is providing an annual environmental monitoring plan for the calendar year 2006. The plan consists of a series of individual work plans describing independent environmental monitoring and surveillance. Oversight of DOE's environmental monitoring and surveillance programs is also described. Chemical and radiological emissions in the air, water, biota, and sediment on the Oak Ridge Reservation and environs are emphasized. The goal is to assure that DOE Oak Ridge Operations has no adverse impact to public health, safety, or the environment. Results from our monitoring and our findings of the quality and effectiveness of the DOE's environmental programs are reported in our quarterly and annual status reports. An annual environmental monitoring report is also provided each spring that details the technical results of these studies.

This plan offers the Department of Energy the opportunity for review and consultation on the division's monitoring activities and to take split samples as needed. For situations such as storm events, non-permitted discharges, emergencies or spills, we may perform short notice or no notice sampling. DOE will be informed as soon as a decision is made to take short notice or no notice samples. Environmental monitoring is a dynamic process and will periodically change. Major changes to this plan will be made in writing to DOE.

The division or the Tennessee Department of Health, Environmental Laboratory and Microbiological Laboratory Organization (Laboratory Services) will process quantitative chemical samples. Laboratory Services has expertise in a broad scope of services and analysis. Certain analyses and Quality Assurance/Quality Control (QA/QC) samples are subcontracted out by Laboratory Services to independent certified laboratories. Bench level QA/QC records and chain of custody records are maintained by Laboratory Services for all samples collected by the division. The Laboratory Services Standard Operating Procedures are followed and also serve as a guide to the division's laboratory procedures. General sampling and analysis methods follow EPA guidelines.

Benthic macroinvertebrates and other biological samples are taxonomically identified at Laboratory Services, in the division's laboratory, or by Laboratory Services subcontractors. Common water quality measurements and radiological readings are done in the field with calibrated instruments. Environmental dosimeters and radon detectors are analyzed by outside vendors and not Laboratory Services. All work follows EPA, state, and instrument manufacturer's protocols as appropriate. Data loggers are used as available to reduce transcription errors.

Air Quality Monitoring

The division's integrated air quality monitoring is designed to verify and enhance the DOE monitoring of the air quality on the Oak Ridge Reservation, as well as the surrounding areas which may be impacted from DOE Oak Ridge Operations. The division implements EPA's Environmental Radiation Ambient Monitoring System (ERAMS) Air Program. We provide radiological surveillance of ambient air quality in the vicinity of the ORR and compare the results to that of the national ERAMS program. A precipitation monitor has been added to the ERAMs system from which radiological contaminants in rain and snow will be assessed. The ORR perimeter program is oversighted. In fact, we have arranged to use DOE's pre-filter media for our own radiological analysis and do direct trend comparisons. Portable samplers are also set up to measure hazardous and radioactive contaminants around DOE demolition and remediation projects. In 2005 we added EMWMF as an air-sampling site for fugitive emissions. Results are used to verify that DOE keeps contamination contained during cleanup and disposal activities. In the event of a large catastrophic release, any of these data could be used for consequence assessment and to guide recovery efforts, even in the community.

Biological/Fish and Wildlife

The division provides independent biological monitoring and oversight on and off the Oak Ridge Reservation to determine the impact of DOE operations. The division works in conjunction with the Tennessee Wildlife Resources Agency (TWRA), the Tennessee Valley Authority (TVA), and with other Tennessee Department of Environment and Conservation offices to coordinate valley wide monitoring efforts related to fishing advisories. Specific contaminant pathways are investigated on the Oak Ridge Reservation as well. Results are used to formulate recommendations on clean up and measure potential human and environmental risk. We are currently measuring impacts to aquatic biota, contamination in geese and deer and other indicator species such as lichens and watercress. We also are mapping invasive plants on a 3000-acre conservation easement.

Drinking Water

Public water systems on the Clinch River and Tennessee River can be adversely impacted by DOE activities on the Oak Ridge Reservation. The division's independent drinking water monitoring supports public water system's monitoring efforts related to releases from the Oak Ridge Reservation. The division implements EPA's Environmental Radiation Ambient Monitoring System (ERAMS) Drinking Water Program. Results are compared to the national program. The state provides labor and EPA provides expendables and analysis. Another note, because DOE plant water distribution systems operate at a fraction of historical capacity and can stagnate, we also monitor chlorine residuals in DOE facilities. The comprehensive goal is to document and trend that systems continue to be safe from radiological, chemical, and bacteriological contamination.

Groundwater Monitoring

The division's groundwater monitoring program provides information about Oak Ridge Reservation releases and potential impacts on health and the environment. Given the implications of contaminant transport off the Oak Ridge Reservation via groundwater, the division will continue its emphasis on the identification of groundwater pathways. These activities include monitoring of water supplies, wells, and springs on and off the ORR and hydrogeological investigations such as aquifer evaluations and dye traces. Integration of groundwater and surface water results refine concepts of groundwater behavior. Much groundwater tracing is opportunistic, as we must take advantage of favorable weather or sinkhole discoveries during construction, etc. Reports by citizens of large springs in the ORR environs are useful to us and guide our sample planning.

Radiological Monitoring

The division's radiological monitoring is directed toward the development of a comprehensive radiological monitoring system as prescribed by the Tennessee Oversight Agreement, Attachment C.2 *"Radiological Oversight."* The primary focus of the program is the detection of radiological contamination with the potential to impact human health and the environment. Our radiological program contributes in all media areas and reviews CERCLA, NEPA, waste disposition, and other projects involving radionuclides. Autonomous monitoring includes facility surveys, gamma monitoring of the ORR and UF_6 yards, footprint reduction surveys, surplus sales survey, and real time gamma monitoring around active demolition and remediation sites. Automated gamma monitoring is being done at the Environmental Management Waste Management Facility in Bear Creek Valley, for example. The DOE weigh scales database is compared to our gamma monitoring data. Using time stamps to match data, we are monitoring radiation readings on waste shipments delivered for disposal and assuring that radioactive shipments are weighed and documented.

Surface Water Monitoring

The division measures trends in the quality of water and sediments in the Clinch River and Oak Ridge Reservation tributaries. Surface water is one of Tennessee's most important economic and environmental resources but local waterways rarely unconditionally meet all designated uses. For example, there are advisories on fish consumption from local reservoirs and streams. Legacy pollution from DOE, other industries, and non-point source origins are continuing problems. Long term monitoring can define success or failure of cleanup actions, source controls, and attenuation. Specifically, we are analyzing water from Bear Creek to isolate legacy source inputs. It is hoped that the long term monitoring strategy for the new Environmental Management Waste Management Facility can be positively affected and that existing sources/pathways can be found, analytically isolated, trended, and remedied. Another perspective, the Clinch and Tennessee Rivers are drinking water sources for several municipalities. Knowing pollutant concentrations has implications for drinking water obtained from surface waters. In 2006, more monitoring and investigation will be done closer to remediation projects and new construction sites such as SNS. We are also doing a significant amount of storm event related sampling. This will give us better resolution in evaluating the success of clean-up and remediation efforts.

Invitation for Public Comment

This plan is published to inform the public about state sampling on the ORR and environs. Any comments from the public on where or how our future sampling should be done are greatly appreciated. Comments can be sent to:

Darlene Seagraves
TDEC DOE-O
761 Emory Valley Road
Oak Ridge TN 37830

Comments can also be sent to darlene.seagraves@state.tn.us or faxed to (865) 482-1835.

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CHAPTER 1 AIR QUALITY MONITORING

Monitoring of Hazardous Air Pollutants at the East Tennessee Technology Park (ETTP)

Introduction

This independent monitoring project is conducted under authority of the Tennessee Oversight Agreement. It is a continuation of the ambient air-monitoring project initiated in 1997 in response to the heightened level of public concern regarding potential impacts to public health from the TSCA Incinerator emissions. Additionally, with the continuation of D&D activities, further analyses of the potential impacts of these projects on the ambient air on and around the ETTP site is warranted.

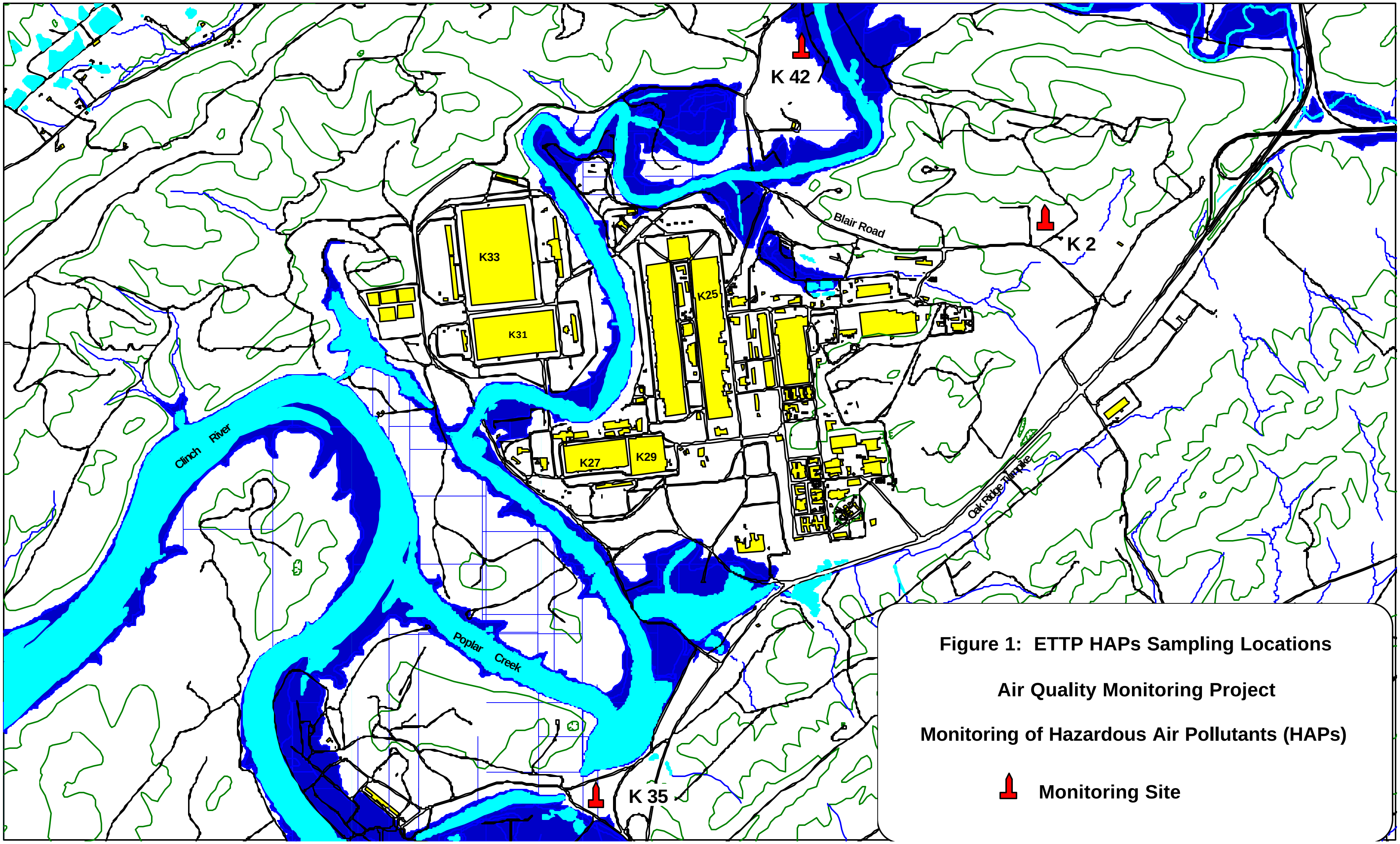
Through use of the division's Hi-Volume ambient air samplers, levels of Arsenic, Beryllium, Cadmium, Chromium, Lead, Nickel and Uranium (as a metal only) in the ambient air at the ETTP site will be monitored. Possible sampling locations have been selected through wind rose data indicating their presence in the prevailing wind flow directions at the ETTP site. The sites are as follows:

- K-2 Blair Road across from the TSCA Incinerator
- Station 42/TSCA-1 on Blair Road and
- Station 35/TSCA-2 site on Gallaher Road. (See Figure 1)

Currently, the monitor has been located at the K-2 site. DOE maintains an air monitoring for metals and radiological emissions at this site. This location was selected on the basis of wind rose data, as well as monitoring data collected by DOE. Although this project will sample for metals only, the Radiological Monitoring Oversight (RMO) program of the Department of Energy Oversight Division (TDEC) will continue ongoing radiological ambient air monitoring on the ETTP site.

Methods and Materials

On a weekly basis sample filters will be collected from the sampler. A composite sample will be analyzed quarterly by a sub-contractor of the state laboratory in Nashville according to EPA Method IO-3.5, determination of metals in ambient air particulate using inductively coupled plasma/mass spectrometry (ICP-MS). The sampler will remain at the K-2 site, which is closest to the TSCA incinerator, throughout most of 2006. However, the option of moving the sampler to one of the other locations listed above or elsewhere around ETTP is a possibility should a need to do so be perceived by the staff. Methods and protocols have been developed based on equipment maintenance manuals supplied by the manufacturer and sampling criteria tailored specifically to this project and DOE-O's mission and staffing levels.


K 42
K 2
K 35
Blair Road
K33
K31
K25
K27
K29
Clinch River
Poplar Creek
Oak Ridge Turnpike
Figure 1: ETTP HAPs Sampling Locations
Air Quality Monitoring Project
Monitoring of Hazardous Air Pollutants (HAPs)
Monitoring Site

At an interval less than two months since the last brush change, the sampler motor will be disassembled and the motor's brushes inspected for condition and evaluated for longevity. When it is not expected that the brushes will last until the next site visit, they will be replaced. Based on experience with the typical lifetime of the sampler motor, it will be changed about twice annually. The sampler will also be inspected to ensure that the orifice remains level and parallel to the ground. At each site visit the sampling cartridge will be removed and replaced with one holding a new filter. The cartridge will be covered both top and bottom, and the sample will be removed at the DOE-O laboratory and placed in a zip-lock bag. The 24-hour chart recording pressure differential will be removed and replaced weekly and its pen trace will be evaluated for average readings for the weekly period. Relevant information will be recorded on the reverse side of the chart. Readings of atmospheric pressure and ambient temperature are to be recorded on the chart, and the reading of the elapsed time indicator will also be taken. Proper chain of custody for samples will be maintained. DOE-O staff will maintain an annual calibration check that will be carried out in accordance with the manufacturer's specifications.

A report will be generated detailing the analytical results from each sampling location. Upon completion of the project a final report will be prepared presenting conclusions regarding ambient air HAPs metals.

Materials required for this project include:

1. Hi-Volume sampler
2. Sampler replacement parts
3. Level
4. Extension cords
5. Tool kit
6. Motor brushes
7. Filters
8. Calibration kit
9. Flow charts
10. Waterproof marking pens
11. Project data/custody forms
12. Plastic sample bags

References

New York State Department of Environment Control, Draft New York State Air Guide-1, *Guidelines for the Control of Toxic Ambient Air Contaminants, Appendix B of Air Guide-1, Ambient Air Quality Impact Screening Analyses*. 1994 Edition.

Operations Manual for GMW Model2000H Total Suspended Particulate Sampling System, 1998 Graseby GMW Variable Resistance Calibration Kit # G2835.

Tennessee Department of Environment and Conservation, TDEC DOE-O Procedure Number: SOP-ES&H-004 Air Monitoring/Air Sampling.

Tennessee Department of Environment and Conservation, *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the state of Tennessee.* Oak Ridge, Tennessee. 2001.

Title 40 CFR Part 266 Appendix V.Boiler and Industrial Furnace Regulations

Thomasson, D.A. 2005. *Health, Safety and Security Plan,* Tennessee Department of Environment and Conservation, Department of Energy Oversight Division, Oak Ridge, Tennessee.

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CHAPTER 1 AIR QUALITY MONITORING

Monitoring of Hazardous Air Pollutants at X-10 and Y-12

Introduction

This independent monitoring project is conducted under authority of the Tennessee Oversight Agreement. It is a continuation of the ambient air-monitoring project initiated in 1998 in response to the public's concern regarding possible health effects resulting from the potential presence of hazardous air pollutants on and around the Oak Ridge Reservation.

Additionally, the continuation of remediation activities at ORNL, and the initiation of D&D activities as well as restart of uranium processing operations at Y-12 National Security Complex, presents an opportunity to further evaluate their impact on the ambient air on and around the these DOE sites.

Levels of Arsenic, Beryllium, Cadmium, Chromium, Lead, Nickel and Uranium (as a metal only) in the ambient air at the Y-12 National Security Complex and ORNL facilities will be determined through use of the Division's Hi-Volume ambient air samplers. The goal of this project will be accomplished through locating samplers at predetermined sampling locations currently in use since the 2004 calendar year monitoring project. These locations were selected based on wind rose data, availability of electrical power, and co-location with DOE and TDEC radiological air monitors. The sites are as follows:

- ORNL: X-10E - ERAMS station east of the main entrance to the site
  X-10W - Station No. 3 west of the site (See Figure 1)

- Y-12: Y-12E - ERAMS station east of the plant entrance
  Y-12W - ERAMS station west of the plant site (See Figure 2)

Although this project will sample for metals only, the Radiological Monitoring Oversight (RMO) program of the Department of Energy Oversight Division (TDEC) will continue ongoing radiological ambient air monitoring on the Oak Ridge Reservation.

Methods and Materials

On a weekly basis, sample filters will be collected from samplers and sent for analysis to the state laboratory in Nashville. Samplers will be placed east of each site, which is generally in the direction of the maximum average wind speed. However, the samplers will remain on trailers and may be moved west of the sites, if desired. Power supply at the X-10E site is provided via a temperature sensitive source. Therefore, during the coldest months, the ORNL sampler may be located at the X-10W site.

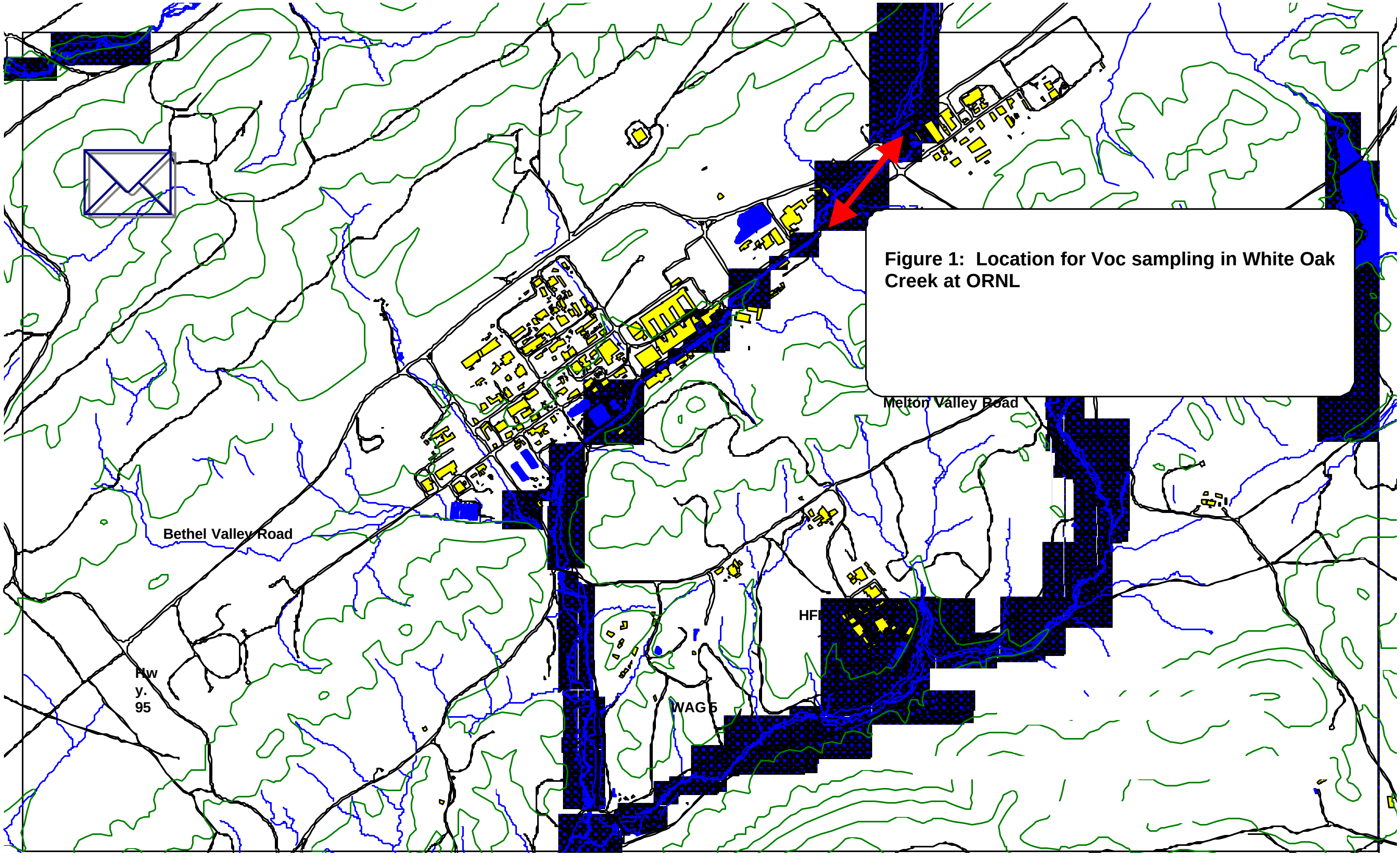

Figure 1: Location for Voc sampling in White Oak Creek at ORNL

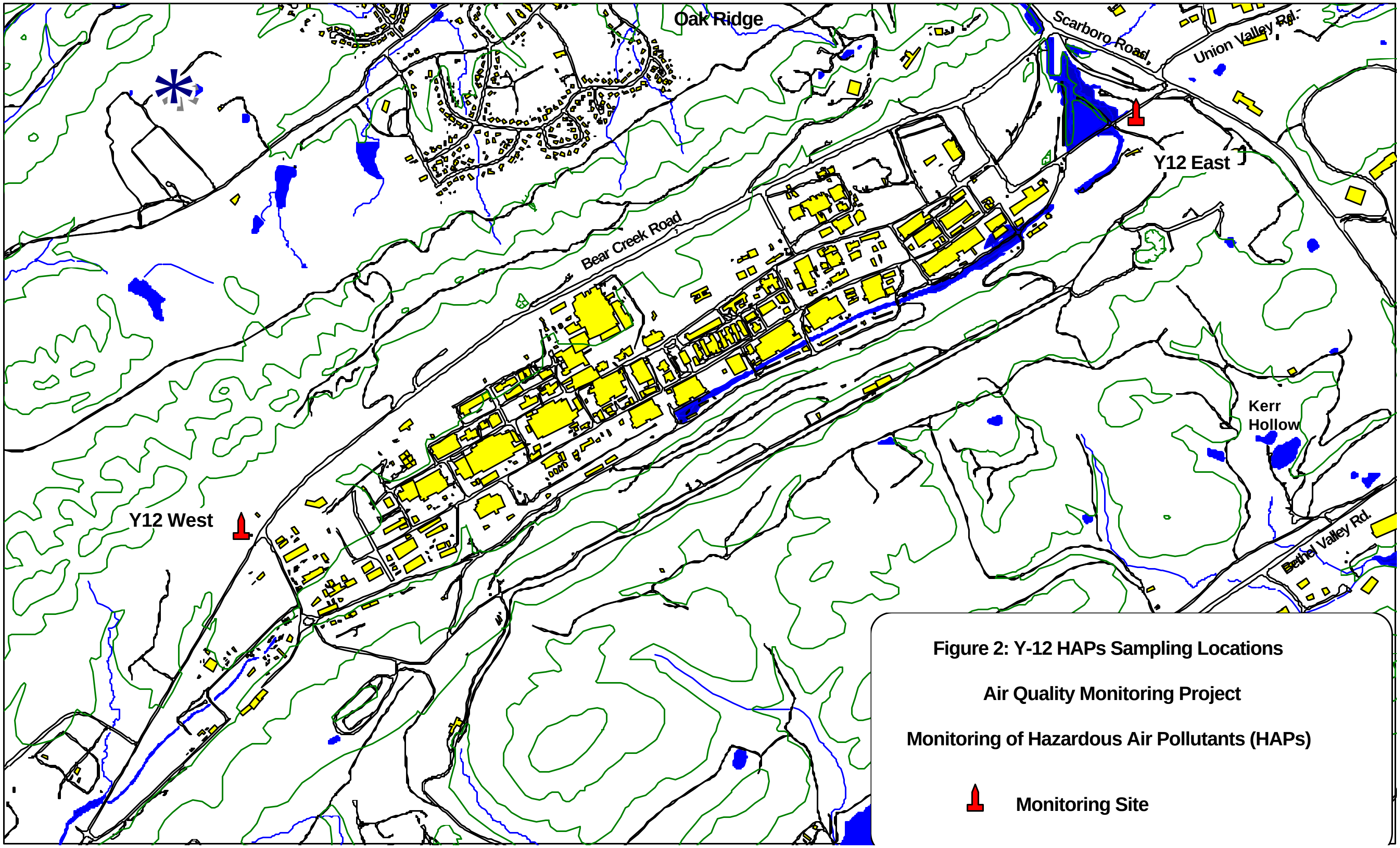

Figure 2: Y-12 HAPs Sampling Locations

Air Quality Monitoring Project

Monitoring of Hazardous Air Pollutants (HAPs)

At an interval less than two months since the last brush change, the sampler motor will be disassembled and the motor's brushes inspected for condition and evaluated for longevity. When it is not expected that the brushes will last until the next site visit, they will be replaced. Sampler motors will be replaced about every six months. The sampler will also be inspected to ensure that the orifice remains level and parallel to the ground. At each site visit the sampling cartridge will be removed and replaced with one holding a new filter. The cartridge will be covered both top and bottom, and the sample will be removed at the DOE-O laboratory and placed in a zip-lock bag. The 24-hour chart recording pressure differential will be removed and replaced weekly, and its' pen trace will be evaluated for average readings for the weekly period. Relevant information will be recorded on the reverse side of the chart. Readings of atmospheric pressure and ambient temperature are to be recorded on the chart, and the reading of the elapsed time indicator will also be taken. Proper chain of custody for samples will be maintained. DOE-O staff will maintain an annual calibration check that will be carried out in accordance with the manufacturer's specifications.

A report will be generated detailing the analytical results from each sampling location. Upon completion of the project, a final report will be prepared presenting conclusions regarding ambient air HAPs metals.

Materials required for this project include:

1. Hi-Volume sampler
2. Trailer
3. Level
4. Extension cords
5. Tool kit
6. Motor brushes
7. Filters
8. Calibration kit
9. Flow charts
10. Waterproof marking pens
11. Project data/custody forms
12. Plastic sample bags

References

New York State Department of Environment Control, Draft New York State Air Guide-1. G*uidelines for the Control of Toxic Ambient Air Contaminants, Appendix B of Air Guide-1, Ambient Air Quality Impact Screening Analyses.* 1994 Edition.

Operations Manual for GMW Model2000H Total Suspended Particulate Sampling System, 1998. Graseby GMW Variable Resistance Calibration Kit # G2835.

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Title 40 CFR Part 266 Appendix V.Boiler and Industrial Furnace Regulations.

Thomasson, D.A. 2005. *Health, Safety and Security Plan,* Tennessee Department of Environment and Conservation Department of Energy Oversight Division, Oak Ridge.

CHAPTER 1 AIR QUALITY MONITORING

Environmental Radiation Ambient Monitoring System (ERAMS) Air Program

Introduction

In the past, air emissions as a consequence of Department of Energy (DOE) activities on the Oak Ridge Reservation (ORR) have been believed to be a potential cause of illnesses affecting area residents. While these emissions have substantially decreased over the years with the decommissioning of various processes, concerns have remained that air emissions from current activities may pose a threat to the health of the public and/or the surrounding environment. As a consequence of the above, the Tennessee Department of Environment and Conservation DOE Oversight Division (the division) will continue three air monitoring programs developed to assess the impact of ORR air emissions on the surrounding environment and the effectiveness of DOE controls and monitoring systems.

The division's Perimeter and Fugitive Air Monitoring Programs (described in associated plans) will focus on monitoring at exit pathways, diffuse emissions, and sites of special interest (e.g., remedial sites). Division participation in EPA's Environmental Radiation Ambient Monitoring System (ERAMS) will supplement these programs and provide verification of state and DOE monitoring, via independent third party analysis.

Methods and Materials

The five ERAMS air monitors will use synthetic fiber filters (ten centimeters in diameter) to collect particulates as air is pulled through the units at approximately 35 cubic feet per minute. The monitors will be operated continuously and the filters will be changed twice weekly (Monday and Thursday) by division staff. As prescribed in *Environmental Radiation Ambient Monitoring System (ERAMS) Manual* (U.S. EPA, 1988), the quantity of radioactivity on each filter will be estimated by staff using one of the division's Geiger-Mueller radiation detectors. The filters will then be mailed to EPA's National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, Alabama for analysis. ERAMS analytical parameters and frequencies are provided in Table 1.

Table 1: EPA Analysis of Air Samples Taken in Association with the Environmental Radiation Ambient Monitoring System

ANALYSIS	FREQUENCY
Gross Beta	Each of twice weekly samples
Gamma Scan	Samples having > 1 pCi/m^3 of gross beta
Plutonium-238, Plutonium-239, Plutonium-240, Uranium-234, Uranium-235, Uranium-238	Semiannually on composite air particulate filters

The approximate locations of the five ERAMS air-monitoring stations are depicted in Figure 1.

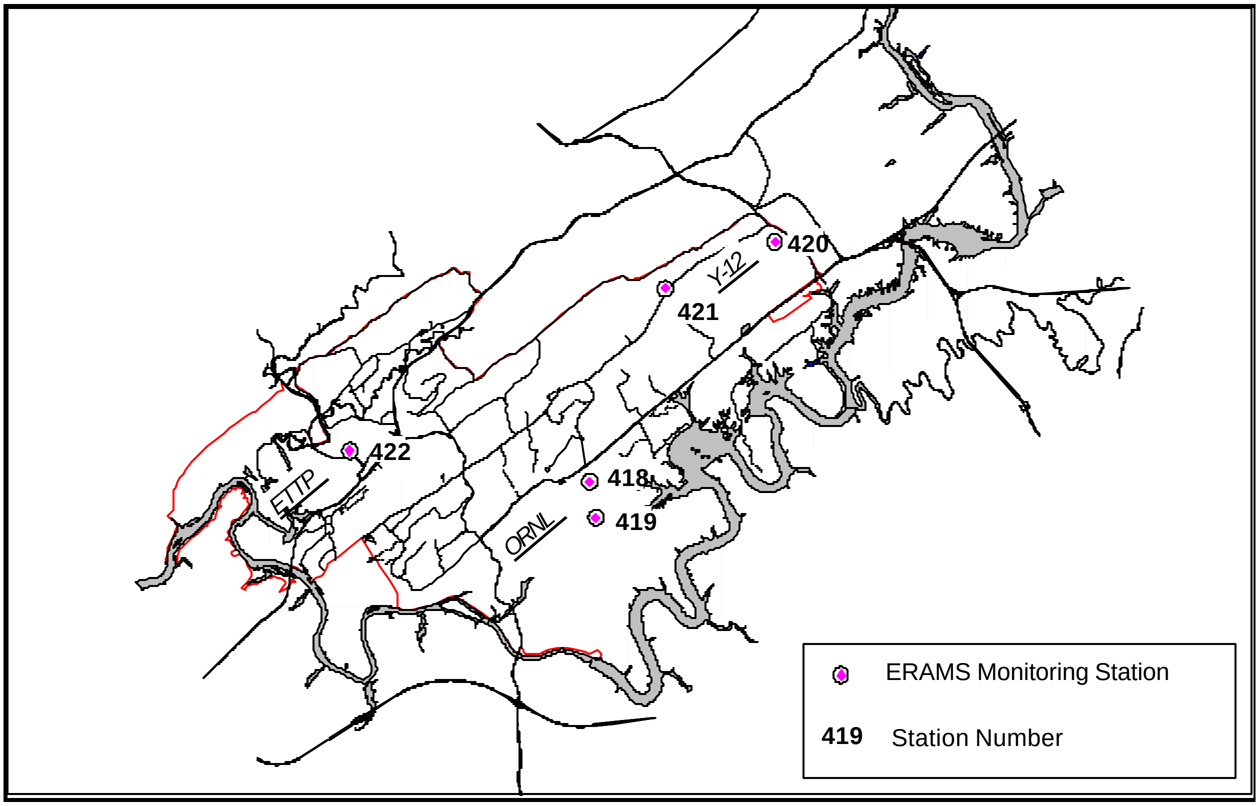

Figure 1: Approximate Locations of Air Stations Monitored in Association with EPA's Environmental Radiation Ambient Monitoring System (ERAMS) on the Oak Ridge Reservation

References

Tennessee Department of Environment and Conservation. 2001. Tennessee *Oversight Agreement, Agreement between the U.S. Department of Energy and the state of Tennessee.* Oak Ridge, Tennessee.

U.S. EPA. 1988. *Environmental Radiation Ambient Monitoring System (ERAMS) Manual*. EPA 520/5-84-007, 008, 009. May, 1988.

U.S. EPA. 1994. *Environmental Radiation Data Report 80*. EPA-402-R-97-004. February, 1997.

Thomasson, D.A. 2005. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation, DOE-Oversight Division. Oak Ridge, Tennessee.

CHAPTER 1 AIR QUALITY MONITORING

Fugitive Radiological Emission Monitoring

Introduction

In 2006, the Tennessee Department of Environment and Conservation DOE Oversight Division (the division), with the cooperation of the Department of Energy and its contractors, will continue monitoring for fugitive radioactive air emissions on and in the vicinity of the Oak Ridge Reservation. This program uses mobile high-volume air samplers to supplement air monitoring performed at fixed locations. In this respect, the high volume monitors, along with more frequent sampling and analysis, provide greater measurement sensitivity and resolution than can be achieved with the low-volume monitors used in the division's Perimeter Air Program. Monitoring performed with the mobile units will primarily focus on nonpoint sources of air emissions and sites of special interest.

Methods and Materials

In 2006, the division will deploy four high-volume air monitors in the program. One of the monitors will be stationed at Fort Loudoun Dam in Loudon County to collect background data. The other three units will be placed at locations where there appears to be a potential for the release of fugitive/diffuse emissions. Two of the samplers are currently positioned to monitor the decontamination and decommissioning (D&D) of the K-25 Process Building and the 1420 Decontamination Facility, both located at ETTP. The third unit has been positioned to monitor waste disposal activities at the Environmental Management Waste Management Facility in Bear Creek Valley. Other locations being considered for monitoring include facilities being renovated as part of the revitalization initiative at ORNL, Y12 D&D activities, and a location near the construction of the Spallation Neutron Source Facility.

The high-volume monitors use 8x10 inch glass fiber filters to collect particulates as air is pulled through the system at a rate of approximately 35 cubic feet per minute. As in the past, airflow through the filters will be calibrated quarterly, using a Graseby General Metal Works Variable Resistance Calibration Kit (#G2835). Samples from the units will be collected weekly and shipped to the state's radiochemical laboratory in Nashville, Tennessee, for analysis. Analysis will include gross alpha, gross beta, and gamma spectrometry with additional analysis performed where merited. To assess the concentrations measured, results from the portable monitors will be compared with the background data and standards provided in the Clean Air Act.

References

Tennessee Department of Environment and Conservation. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the state of Tennessee*. Oak Ridge, Tennessee. 2001.

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CHAPTER 1 AIR QUALITY MONITORING

Ambient VOC Monitoring of Air on the Oak Ridge Reservation

Project Description

The objective of this monitoring program is to perform ambient monitoring of air for volatile organic compounds (VOC) at selected locations on the Oak Ridge Reservation (ORR) to determine the effects of activities and practices on the ORR. Using methods outlined in the *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual USEPA Region 4* (November 2001).

Introduction

Ambient air samples will be collected at several ORR locations and analyzed to independently assess the "overall health" of the ambient environments and to measure the degree of impact from present DOE operations. The division conducts several periodic air sampling efforts on the ORR. However, ambient VOC monitoring has not been attempted until this project: Locations to be monitored will be Bear Creek valley, Mitchell Branch, and Union Valley east of Y-12.

Samples will be transported to the Tennessee state laboratory in Knoxville and analyzed for Volatile Organic Compounds, and radionuclide constituents. EPA approved methods will be used for the collection of the air samples. All work associated with this program will be in compliance with the division's Health, Safety, and Security Plan.

Methods and Materials

Air samples will be collected and processed following EPA standard operating procedures (SOP). Briefly, samples will be collected from areas that are known VOC emitters. Ambient air will be collected using Summa canisters or equivalent as grab samples. The container is evacuated and the air sample is drawn into the canister. If possible electronic valving will be obtained to control the flow of sample into the canister to sample over a period of time. The container will be labeled externally with site-specific information and transported to the Tennessee Department of Health environmental laboratory in Knoxville for VOC analysis.

Samples will be collected quarterly for the three sites. Two samples will be collected from each site during each quarter to more accurately gauge the possible contaminants in the air. Therefore one sample will be collected in the morning with still air and one in the afternoon with moving air.

Schedule and sampling locations in kilometers (mile equivalents):

Bear Creek: BCK 9.6 (6.0). Twice each quarter
JES Seep Twice each quarter
Mitchell Branch: MIK 0.71 (0.44). Twice each quarter
Scarboro Creek: SCR 7.19 (4.45) Twice each quarter
Lila's Leak P-3 Pond ETTP Twice each quarter
J. A. Jones Spring ETTP Twice each quarter
SW-31 ETTP Twice each quarter

References

Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, U.S. Environmental Protection Agency, Region IV. 960 College Station Road, Athens, Georgia. 2001.

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CHAPTER 1 AIR QUALITY MONITORING

Oak Ridge Reservation Perimeter Ambient Air Monitoring Program

Introduction

The Tennessee Department of Environment and Conservation, DOE Oversight Division (the division), with the cooperation of DOE, will provide radiochemical analysis of air samples taken from twelve low volume air monitors located on and in the vicinity of the Oak Ridge Reservation (ORR). Data derived from the program, along with information generated by the other division air monitoring programs, will be used to: (1) assess the impact of DOE activities on the public health and environment, (2) identify and characterize unplanned releases, (3) establish trends in air quality, and (4) verify data generated by DOE and its contractors.

Methods and Materials

The twelve air monitors that will be used in the program are owned by DOE and DOE contractors are responsible for their maintenance and calibration. Nine of the units are a component of DOE's ORR perimeter air monitoring system. The remaining three monitors were previously used by the Y-12 complex in their perimeter air monitoring program.

Each of the monitors use forty-seven millimeter borosilicate glass fiber filters to collect particulates as air is pulled through the units. The ORR perimeter monitors employ a pump and flow controller to maintain airflow through the filters at approximately two standard cubic feet per minute. The Y-12 monitors control airflow with a pump and rotometer set to average approximately two standard cubic feet per minute.

Air filters from the monitors will be collected bi-weekly and sent by certified mail to the state's radiochemical laboratory in Nashville, Tennessee for analysis. Analysis will include gross alpha and gross beta on the biweekly samples. Gamma spectrometry will be performed on samples that exhibit elevated gross results and annually on composite samples.

The twelve air monitoring stations in the program are listed in Table 1. Eleven of these stations are located around the perimeter of the ORR and Y-12 facility. The twelfth site is the background station located near Fort Loudoun Dam in Loudon County.

Table 1: Perimeter Air Monitoring Stations

Station	Location	County
4	Y-12 Perimeter near portal 2	Anderson
5	Y-12 Perimeter near Building 9212	Anderson
8	Y-12 Perimeter west end	Anderson
35	East Tennessee Technology Park	Roane
37	Bear Creek at Y-12	Roane
38	Westwood Community	Roane
39	Cesium Fields at Oak Ridge National Laboratory	Roane
40	Y-12 East	Anderson
42	East Tennessee Technology Park off Blair Road	Roane
46	Scarboro Community	Anderson
48	Deer Check Station on Bethel Valley Road	Anderson
52	Fort Loudoun Dam (Background Station)	Loudon

Figure 1 depicts the approximate locations of the monitoring stations.

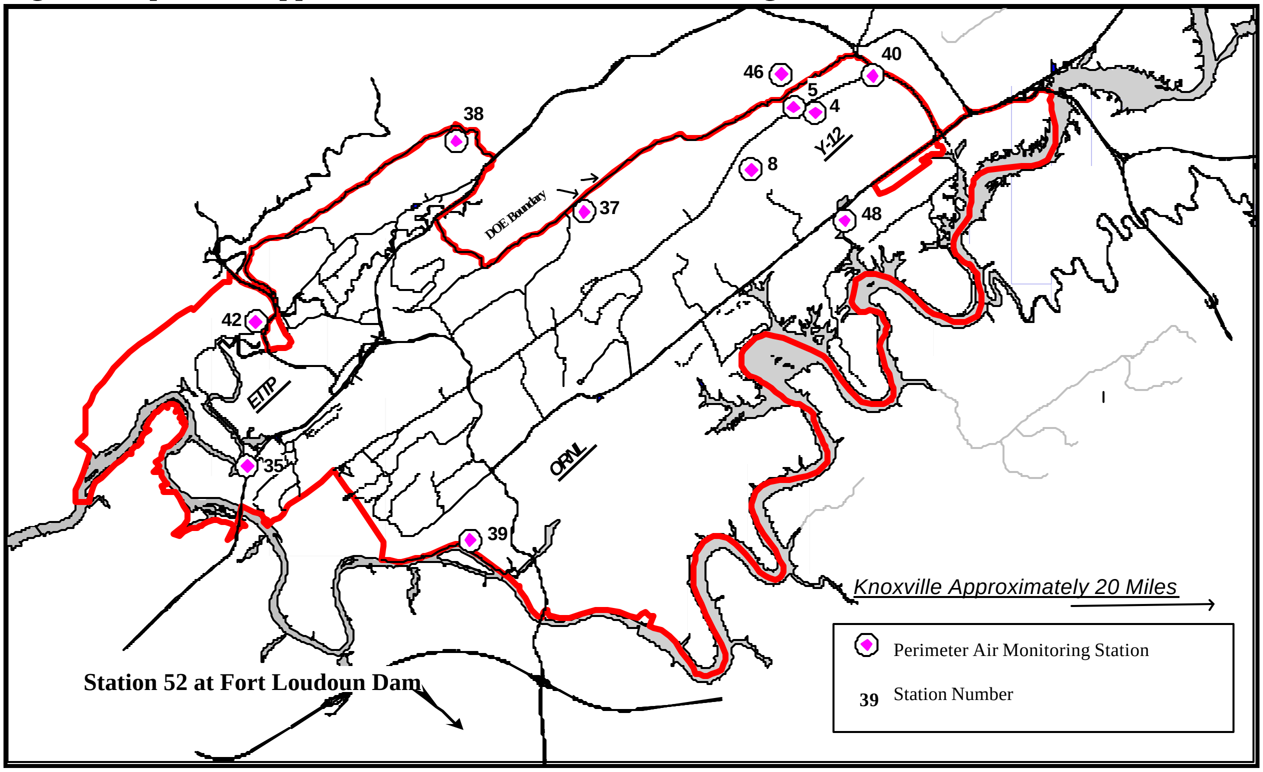

Figure 1: Approximate Location of Oak Ridge Reservation and Y-12 Perimeter Air Monitoring Stations

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CHAPTER 1 AIR QUALITY MONITORING

Environmental Radiation Ambient Monitoring System (ERAMS) Precipitation Program

Introduction

A portion of the effluents suspended in the atmosphere as a consequence of air releases on the Oak Ridge Reservation are washed-out during rain events and carried to the earth's surface with the precipitation. To assess the relevance of radioactive contaminants deposited in this manner, the Tennessee Department of Environment and Conservation's DOE Oversight Division arranged to participate in precipitation monitoring sponsored by EPA's Environmental Radiation Ambient Monitoring System. At this point, EPA has provided only one sampler, but additional units can be manufactured by division staff, if merited.

The ERAMS precipitation sampler has been stationed near the High Flux Isotope Reactor and the Radiochemical Engineering Development Center in Melton Valley at the Oak Ridge National Laboratory. Three of four tritium results received to date were among the highest reported over the last two years for the forty-one stations in the ERAMS program (Figure 1). Other sites under consideration for precipitation monitoring include the TSCA Incinerator and an off-site location.

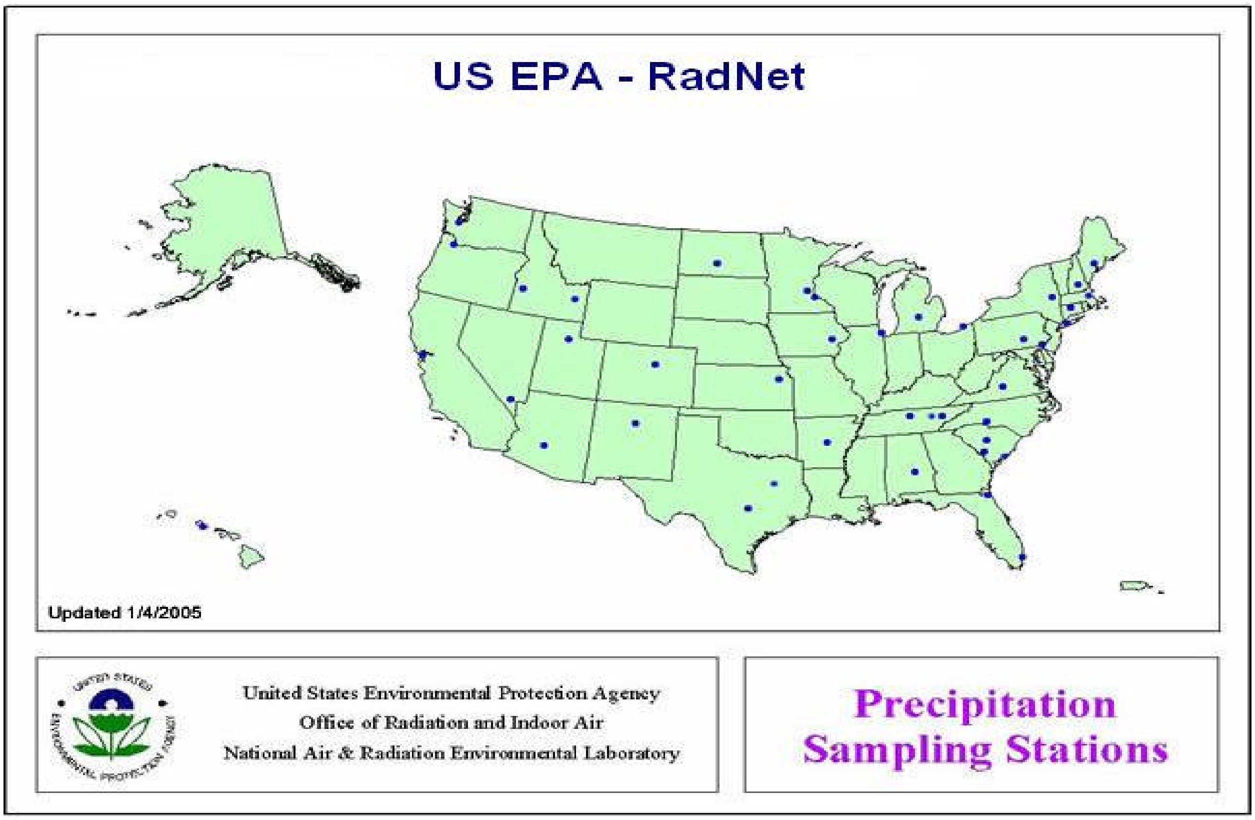

Figure 1. EPA Environmental Radiation Ambient Monitoring System Precipitation Monitoring Stations

Methods and Materials

The ERAMS precipitation sampler uses a 0.5 square meter fiberglass collector, which drains into a five-gallon plastic container. The quantity of precipitation collected in the container will be checked twice weekly. When at least two liters of precipitation have accumulated, a sample will be collected in a four-liter cubitainer. After processing, the samples will be shipped to EPA's National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, Alabama for analysis. Associated analytical parameters and frequencies are provided in Table 1. The results will be reported on EPA's RadNet website (http://www.epa.gov/enviro/html/erams) and annually in the division's Environmental Monitoring Reports.

Table 1: EPA Analysis of Precipitation Samples Taken in Association with the Environmental Radiation Ambient Monitoring System

ANALYSIS	FREQUENCY
Gross Beta	Monthly from composite samples
Gamma Scan	Monthly composite samples having > 1 pCi/m^3 of gross beta
Tritium	Monthly from composite samples

References

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CHAPTER 2 BIOLOGICAL/FISH AND WILDLIFE

2006 Plant Surveys (Field Botany) Environmental Monitoring Plan

Introduction

Vascular plant field surveys on portions of the Oak Ridge Reservation (ORR) were initiated during mid-2003 by division staff. For example, both rare (threatened & endangered species, i.e., “T & E species”) and invasive (exotic or non-native) plants were mapped on the Blackoak Ridge (proposed) conservation easement parcel (to date have covered about 60 percent of 3000 acres). Much field reconnaissance work remains to be completed in 2006 on this and other areas of the ORR, i.e., land parcels to be released by DOE, various road-widening and construction projects, etc. Additional botanical projects that will be continued during 2006 include sampling, monitoring and taxonomy of photosynthetic protists (non-vascular aquatics) as oversight of the ORNL biological monitoring and abatement program’s (BMAP) toxicity and bioaccumulation assessment of periphyton in East Fork Poplar Creek.

Major functions and focus of the project include: (1) provide oversight support and botanical expertise locally to the TDEC Division of Natural Heritage as needed relating to ORR issues, especially T & E species. (2) inventory and map the biological diversity that exists on the ORR to provide floristics survey information about the ORR’s plant species. (3) independently monitor and confirm biological survey and sampling information provided by DOE. (4) protect plants and natural communities (including natural areas) that represent biological diversity on the ORR. (5) provide flexibility in biomonitoring the full spectrum of the plant kingdom taxa (both vascular and non-vascular plants) as recognized by the International Code of Botanical Nomenclature (ICBN). (6) provide field oversight during DOE subcontractor (and/or BMAP) vascular plant surveys on ORR projects (i.e., road construction projects, land transfers, etc.).

This project will incorporate the division’s oversight role of environmental surveillance and monitoring. Additionally, several federal and state laws support this effort: (1) the federal Endangered Species Act of 1973 (ESA), as amended, provides for the inventory, listing, and protection of species in danger of becoming extinct and/or extirpated, and conservation of the habitats on which such species thrive, (2) the National Environmental Policy Act (NEPA), requires that federally-funded projects avoid or mitigate impacts to listed species, (3) the Tennessee Rare Plant Protection and Conservation Act of 1985 (Tennessee Code Annotated Title 11-26, Sects. 201-214), provides for a biodiversity inventory and establishes the State list of endangered, threatened, and special concern taxa, (4) National Resource Damage Assessments (NRDA) as directed by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by SARA (Superfund Amendments and Reauthorization Act of 1986), relating to damages to natural resources on the ORR.

Methods and Materials

Field mapping of native and invasive plant species will utilize field stations (50 foot diameter mini-plots) at pre-selected intervals (i.e., grid patterns, traverses, etc.) based on specific reconnaissance projects. Unusual or rare plants will be located and mapped, if found between these intervals. Sometimes, spot locations of plant taxa may be recorded while on water or sediment sampling field trips. Generally, field biodiversity inventories will begin with existing roads and trails, then transects will be walked cross-country (similar to a “timber cruise”) in generally north-south, east-west traverses to complete a grid pattern of coverage over the parcel.

Habitats such as small drainage ravines, floodplains, wetlands, watersheds, sub-watersheds, sinkholes, cedar barrens, rock outcroppings, cliffs, springs, caves, etc. will be field surveyed for plant taxa. Field surveys are designed to locate and identify T & E plant species, invasive plant species, aquatic and wetland taxa (including algae).

Each field station (mini-plot) will be mapped and located using a Global Positioning System (GPS) hand-held field unit (Garmin™). Each field station will be defined as a 50-foot circle from center point or circumference. Plant taxa will be organized and compartmentalized as: canopy, subcanopy, shrub, herbaceous, and groundcover layers. Digital camera images will be made at most field sites to record and document plant taxa. Microscopy images of algal taxa will be recorded with the digital camera as well. Additionally, the boundaries of the pine deadfall areas (pine-beetle devastated areas) will be mapped whenever possible in the field. These sites may become important ecological study areas to determine if native climax species or invasives will re-establish here.

No sampling of plant species for the purpose of generating analytical data (bioaccumulation data) is envisioned for this project. However, benthic algae samples may be collected from either artificial substrates or natural substrates for taxonomic and stressed community recovery determinations (for protocols refer to Patrick 1973, Porter 1993, Hawkins et al. 1998, & Barbour et al. 1998). Terrestrial plant species may be collected for preservation as herbarium specimens (vouchers). The sample will be collected as much as possible with either flower or fruit, then pressed and dried, and mounted on herbarium paper with appropriate identification labels. These are quite useful for training purposes but more importantly to properly document and confirm plant species (especially rare species) encountered in the field. Care will be taken while collecting plant specimens so as not to destroy or damage a rare plant colony.

Field data sheets (survey logs) will be recorded for each survey station and later placed in a database for inclusion in the environmental monitoring report. Maps will be prepared with MapInfo™ to illustrate locations of all field stations with plant data, geologic features and other pertinent biological habitat and field data.

Field monitoring methods and health and safety procedures will follow the guidelines in the division's *"Standard Operating Procedures"* and *"Health, Safety, and Security Plan."*

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CHAPTER 2 BIOLOGICAL/FISH AND WILDLIFE

Benthic Macroinvertebrate Biomonitoring Using a Semi-Quantitative Approach: Rapid Bioassessment Protocol (RBP III)

Project Description

The objective of this monitoring program is to perform biological monitoring on streams effected by activities and practices on the Oak Ridge Reservation (ORR) using methods outlined in the *State of Tennessee Department of Environment and Conservation (TDEC) Division of Water Pollution Control (WPC) Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys* (March 2002, Revised November 2003).

Introduction

Because benthic macroinvertebrates are relatively sedentary and long lived, they are excellent indicators of the "overall health" of an aquatic system. In systems where the source of the toxicant is non-point (e.g. runoff or seeps) or where the combined effects of pollutants in a complex effluent exceed individual toxicity (synergism), benthic macroinvertebrate communities may be one of the only means of evaluation.

Benthic macroinvertebrates are collected on various ORR streams and analyzed to independently assess the "overall health" of the aquatic environments and to measure the degree of impact from past and present DOE operations. The division conducts annual semi-quantitative RBP III biomonitoring on the following ORR streams: Bear Creek, Mitchell Branch, White Oak Creek, Melton Branch, and East Fork Poplar Creek. Benthic samples are also collected from Clear Creek near Norris Dam serving as an ecoregion reference site for all ORR test sites. Three (3) sites will be sampled for qualitative purposes at no cost. Laboratory results from samples collected at Ernie's Creek and Scarboro Creek in 2005 suggest that additional data is needed to make an accurate assessment of stream conditions. Therefore, benthic samples will be collected at these two sites in 2006 for qualitative analyses. The third sampling site will be determined at a later date.

Surface water samples will be collected semi-annually at all sites and will compliment the macroinvertebrate sampling. Water samples will be transported to the Tennessee state laboratory in Knoxville and analyzed for bacteria, nitrates, hardness, metals, mercury, and radionuclide constituents. Sulfates will also be analyzed in East Fork Poplar Creek, Hinds Creek, and Clear Creek. EPA approved methods will be used for the collection of the water samples. All work associated with this program will be in compliance with the division's Health, Safety, and Security Plan.

Methods and Materials

Benthic macroinvertebrate samples will be collected and processed following TDEC Water Pollution Control (WPC) standard operating procedures (SOP). Briefly, samples will be collected from two riffles at each site with the use of a kick net. Both samples will be composited and transferred into one sample container. The container will be labeled internally and externally with site-specific information and stored in the TDEC DOE-O laboratory for future processing. Standard methods will be altered when sampling lower White Oak Creek due to the presence of radioactive contamination in the stream sediment. The two kick samples will be combined in a five-gallon bucket, creek water is added and the sample swirled to suspend the lighter material (invertebrates). The elutriate will then be poured through a sieve. This process will be repeated five times collecting the majority of organisms. Any material not used will be returned to the creek. Detailed sampling procedures can be obtained by referring to the TDEC WPC SOP.

Once collections have occurred at all sites the semi-quantitative samples will be transported to the State laboratory in Nashville for processing. Laboratory sample analysis will include the identification and enumeration of the benthic macroinvertebrates and data reduction. Using the raw benthic data from the semi-quantitative subsamples, a numerical value will be generated for seven biometrics. These metrics include (1) EPT (Ephemeroptera, Plecoptera, and Trichoptera) Richness, (2) Taxa Richness, (3) Percent OC (oligochaetes and chironomids), (4) Percent EPT (EPT abundance), (5) NCBI (North Carolina Biotic Index), (6) Percent Dominant (Percent contribution of the single most dominant taxon), and (7) Percent Clingers (Percent contribution of organisms that build fixed retreats or have adaptations to attach to surfaces in flowing waters). After values have been calculated for the metrics, a score of 0, 2, 4, or 6 is assigned to each metric based on comparison to the ecoregion reference database. The seven scores are totaled and the site's biological condition is determined. Metric equations and the biocriteria used to determine biological condition can be obtained by referring to the TDEC WPC SOP.

Sampling locations in kilometers (mile equivalents) for RBP III sites:

East Fork Poplar Creek: EFK 25.1 (15.6), EFK 24.4 (15.2), EFK 23.4 (14.5), EFK 13.8 (8.6), and EFK 6.3 (3.9). Reference site: Hinds Creek HCK 20.6 (12.8). All sites will be sampled within a three-day time span in April or May.
Bear Creek: BCK 12.3 (7.6) and BCK 9.6 (6.0). Reference site: Mill Branch MBK 1.6 (1.0). All sites will be sampled within a three-day time span in April or May.
Mitchell Branch Creek: MIK 0.71 (0.44) and MIK 0.45 (0.28). Reference sites: MIK 1.43 (0.89). All sites will be sampled within a three-day time span in April or May.
White Oak Creek: WCK 2.3 (1.4), WCK 3.4 (2.1), and WCK 3.9 (2.4). Reference site: WCK 6.8 (4.2). All sites will be sampled within a three-day time span in April or May.
Melton Branch: MEK 0.3 (0.2)
Clear Creek: CCK 1.45 (ecoregion reference site). This site will be sampled in April or May.

References

State of Tennessee Department of Environment and Conservation Division of Water Pollution Control Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys, March 2002, Revised November 2003.

Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, U.S. Environmental Protection Agency, Region IV. 960 College Station Road, Athens, Georgia. 1996.

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CHAPTER 2 <u>BIOLOGICAL/FISH AND WILDLIFE</u>

Diatom (Periphyton) Environmental Monitoring Plan

Introduction

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (TDEC-DOE-O), Environmental Monitoring and Compliance Section (EMC) will continue efforts to characterize diatom assemblages in order to assess the water quality of watershed streams within and around the Oak Ridge Reservation (ORR). This independent monitoring program will support other DOE-O environmental monitoring programs in obtaining information about possible impacts to public health and the environment from past and present DOE ORR activities. Algae (periphyton, including diatoms, etc.) respond rapidly and sometimes predictably to a wide range of pollutants and provide potentially useful early warning signals of deteriorating water quality conditions (see Figs. 1-3). Because of their position at the base of aquatic food webs, algal indicators provide unique data concerning lotic and lentic aquatic ecosystem health. Diatoms are routinely used to assess water quality, and the literature suggests that they are excellent biological indicators for many types of pollution in aquatic systems (Lowe, 1974, Patrick & Palavage 1994, Kelly et al. 1995). During 2006, periphyton samples will be collected from artificial substrates ("periphytometers") monthly from riffle zones (if possible, along unshaded portions of stream riparian zones) in four ORR watersheds (see Maps 1-3) during the winter, spring, summer and fall seasons. The main objectives of this proposed diatom monitoring and sampling project include: (1) oversight the ORNL biological monitoring and abatement program (BMAP) periphyton monitoring task, (2) determine composition and taxonomy of the taxa comprising the periphyton community in each watershed, (3) investigate and determine pioneering and climax diatom taxa, (4) investigate longitudinal variation in diatom community structure (upstream versus downstream environments), and (5) to complement the DOE-Oversight Division's comprehensive and integrated monitoring programs.

Benthic algal communities, especially diatoms, have a rapid response and recovery time because of their relatively short life cycle (as compared to fish or macroinvertebrates) and their ability to quickly re-colonize formerly disturbed or impacted sites; the diatom community is very sensitive to nutrient enrichment as well as other stressors (Stevenson et al. 2001). Biomonitoring of East Fork Poplar Creek (EFPC) by the ORNL BMAP team has been an ongoing affair since 1985, and involves several tasks such as aquatic toxicity and bioaccumulation, benthic macroinvertebrates, fish community studies, and periphyton studies. These activities are designed to monitor the stream health and recovery of the creek due to decades of contaminated discharges from the Y-12 Plant (now known as the Y-12 National Security Complex & currently managed by BWXT for the U.S. Department of Energy) where nuclear weapons components have been machined and manufactured since the mid-1940s. Releases to the aquatic environment have included heavy metals such as zinc, mercury, and cadmium, volatile organic compounds (VOCs), and radionuclides. Relevant to this endeavor is the determination of natural variation in community structure and morphological growth forms (adaptation) in response to these environmental insults, and the resultant longitudinal variation in diatom community composition of East Fork Poplar Creek (upstream EFPC vs. downstream EFPC…about 10 km apart).

Ecology and Description of Periphyton in Aquatic Environments

Periphyton is a complex matrix of mostly benthic algae (including diatoms), heterotrophic microbes, bacteria, fungi, and protozoa attached to submerged substrates in almost all aquatic ecosystems (both lotic and lentic habitats). Periphyton is an important primary producer in the food web and is an important food source for invertebrates and some fish (stonerollers, etc.), and can be a sorber of contaminants plus an important bioindicator of water quality (modified from USDOE 2001). Diatoms, a major component of periphyton, are unicellular microscopic "plants" (actually photosynthetic protists with chloroplasts) that are members of the algal class Bacillariophyceae. There are two main groups of diatoms: Centrales (radially symmetrical in valve view) and Pennales (bilaterally symmetrical/asymmetrical, or "canoe-shaped"). Diatoms colonize nearly every available aquatic habitat and are unique in that they have siliceous cell walls called valves that are held together by connecting bands (cingulum) called girdle bands. These valves together form a silicified "jewel box" with two overlapping "frustules." The cell wall structure, ornamentation, size, and shape are the main diagnostic features in determining and keying-out a diatom's taxonomic classification (Stoermer and Smol, 1999). To obtain accurate taxonomic identifications, the diatom sample must first be "cleaned" prior to making permanent slides which involves boiling the material in acid to clear the diatoms of all organic matter (plastids, chloroplasts, etc.) such that all that remains are silicified frustules. An important point to remember is that diatom taxonomic keys are designed for identification of cleaned frustules. Under the microscope (@ 100x-400x magnification) the diatoms will either be seen in girdle view or valve view from which taxonomic identifications are determined. Another diagnostic feature of pennate diatoms is the presence of a raphe (longitudinal slits on the face of the valve) or pseudoraphe (longitudinal clear space near the center of the valve). The pennate diatoms with raphe are referred to as "raphids" and those without raphe as "araphids" (John 2000). The shape and orientation of the raphe/pseudoraphe is another important morphological character for diatom taxonomy. The purpose of the raphe/pseudoraphe may be for motility of the diatom where mucilage is secreted, i.e., cytoplasmic streaming (Smith 1950). Many diatom taxa are enclosed in a gelatinous sheath (or are "tube dwellers") which is an adaptation for attachment to substrates in lotic aquatic habitats; the tubes are made of mucopolysaccharides (John 2000). Most plants have gone through evolutionary adaptations to cope with the force and conditions that swift running water brings (diatom genera like *Cymbella* and *Rhoicosphenia* have mucilage stalks that attach to substrates). The mucilaginous stalks or gelatinous sheaths are composed of polysaccharides secreted by the diatoms and creates slimy, slippery coatings on substrates such as submerged rocks, logs, sediments, and macrophytes (this is often the reason creek rocks are so slippery when stepped on). Such adaptations have allowed a number of species to successfully take advantage of the lotic community as their ecological niche (from Biology-online, 2004).

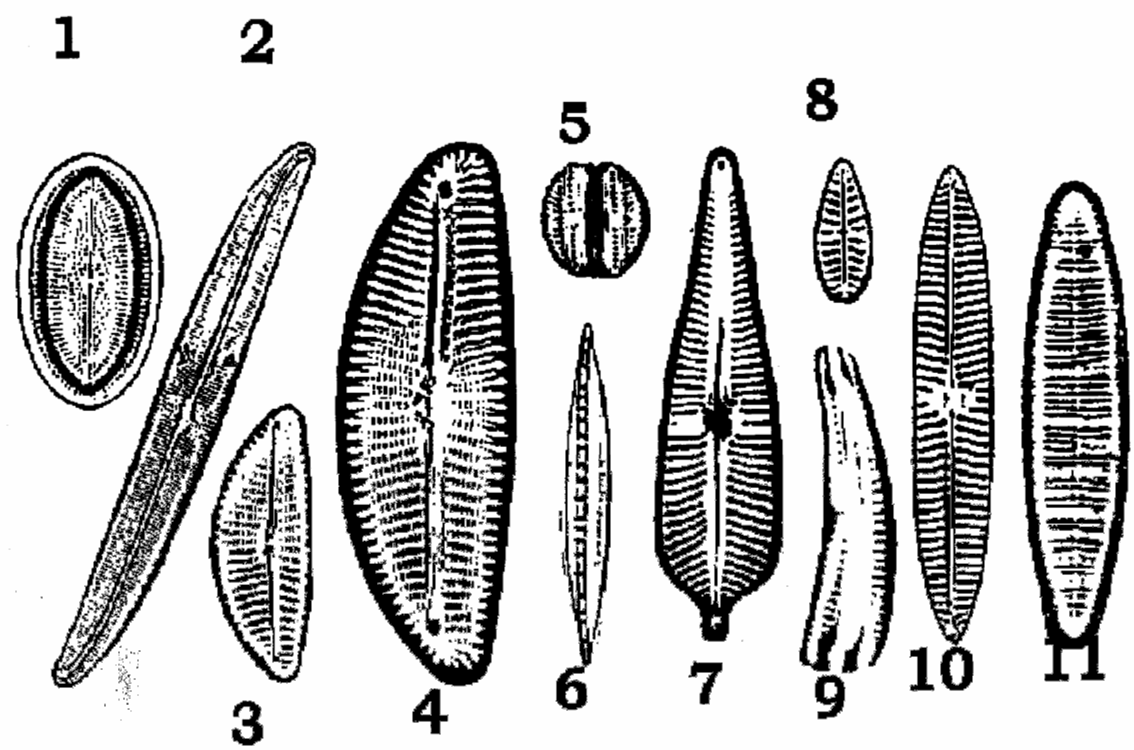
Diatoms exhibit high variation in sexual reproduction and life cycle patterns. The diatom life cycle involves vegetative cell division, formation of auxospores, and sexual reproduction by isogamy (fusion by similar gametes), anisogamy (fusion of dissimilar gametes), or oogamy (fertilization of egg by spermatozoid); the chloroplasts are usually golden-brown to green and the dominate pigments are chlorophyll "a" and chlorophyll "c" including the accessory pigment fucoxanthin (John 2000). Diatoms are important in global cycling of silica and carbon, maintaining fisheries, and also maintaining a dynamic population of varying size (John 2000). Diatoms have various distributions within the aquatic habitat. Some free float (euplanktonic), attach to plants (epiphytic), attach to animals (epizooic), and attach to rocks and other hard substrates (epilithic) (EPA, 1974). Because diatoms colonize diverse habitats, it is important to perform consistent sampling procedures (Figs.10-13).

Periphyton as Bioindicators

A simple chemical analysis of a stream may not provide an accurate assessment of instream conditions. Many factors influence the spatial and temporal chemistry of a stream. Some factors include dilution and absorption rates, concentration, contaminant source location, percentage of CPOM/FPOM (coarse particulate organic matter/fine particulate organic matter) present, and chemical interactions with geological substrates. A biological sampling program is a useful tool that, when supported with a chemical profile, can provide a more reliable assessment of the overall health of a stream. Diatoms make excellent biological indicators because they possess varying sensitivities to environmental stressors and allow a measurement of the rate of change in water quality (Dixit et al., 1992). Studies that use diatoms as biological indicators of water quality have been conducted for many years (Lange-Bertalot, 1979; Shoeman, 1972). In the early years of diatom research, Kolkwitz and Marsson (1908) stated that certain species of algae could be used as environmental indicators and provided an algal classification scheme based on pollution tolerance. Round et al. (1990) provides three lists of diatom species with varying sensitivities for diagnostic comparison as follows (Figures 1-3):

FIGURE 1: SENSITIVE GROUP OF DIATOM TAXA

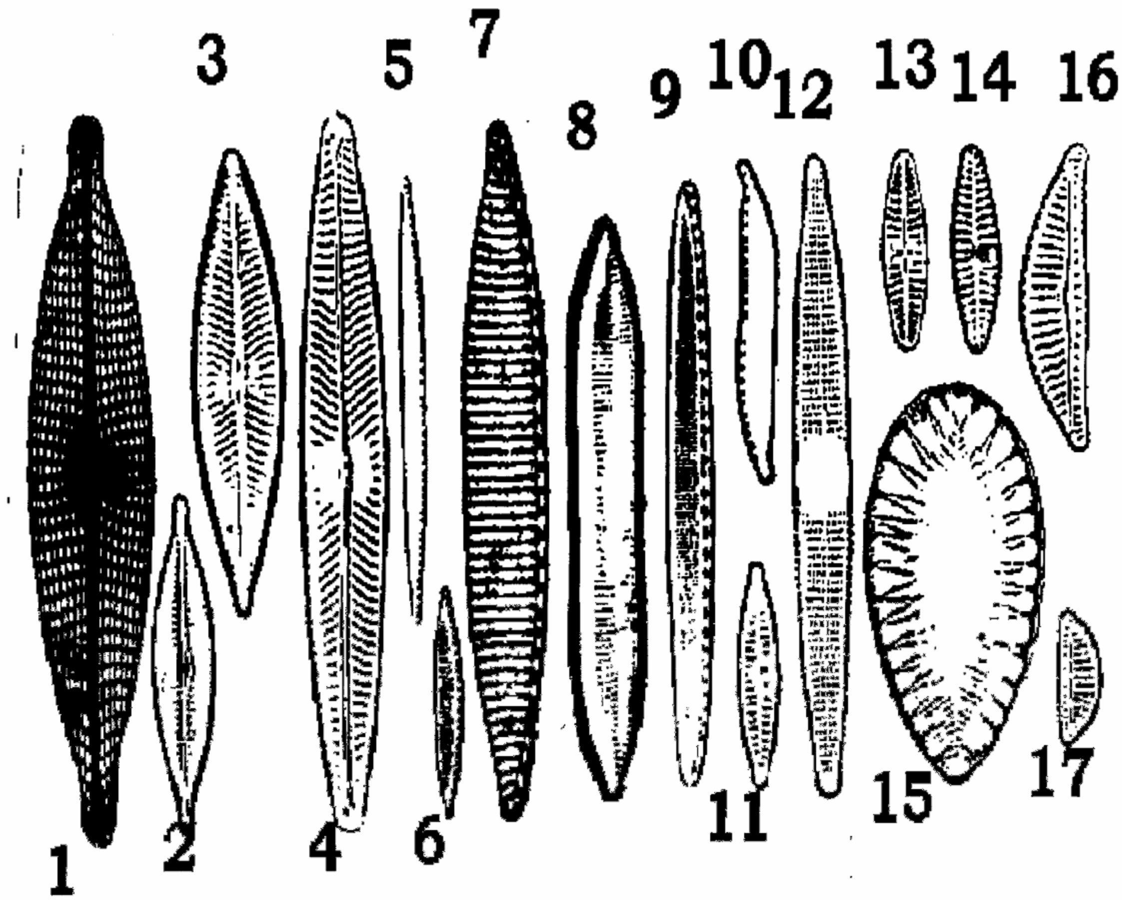
Sensitive Group of Species



1 Cocconeis placentula........7 Gomphonema augur
2 Gyrosigma nodiferum........8 Gomphonema olivaceum
3 Cymbella caespitosum......9 Rhoicosphenia abbreviata
4 Cymbella prostrata..........10 Navicula gracialis = tripunctata
5 Amphora pediculus..........11 Diatoma vulgare
6 Nitzschia dissipata

FIGURE 2: TOLERANT GROUP OF DIATOM TAXA

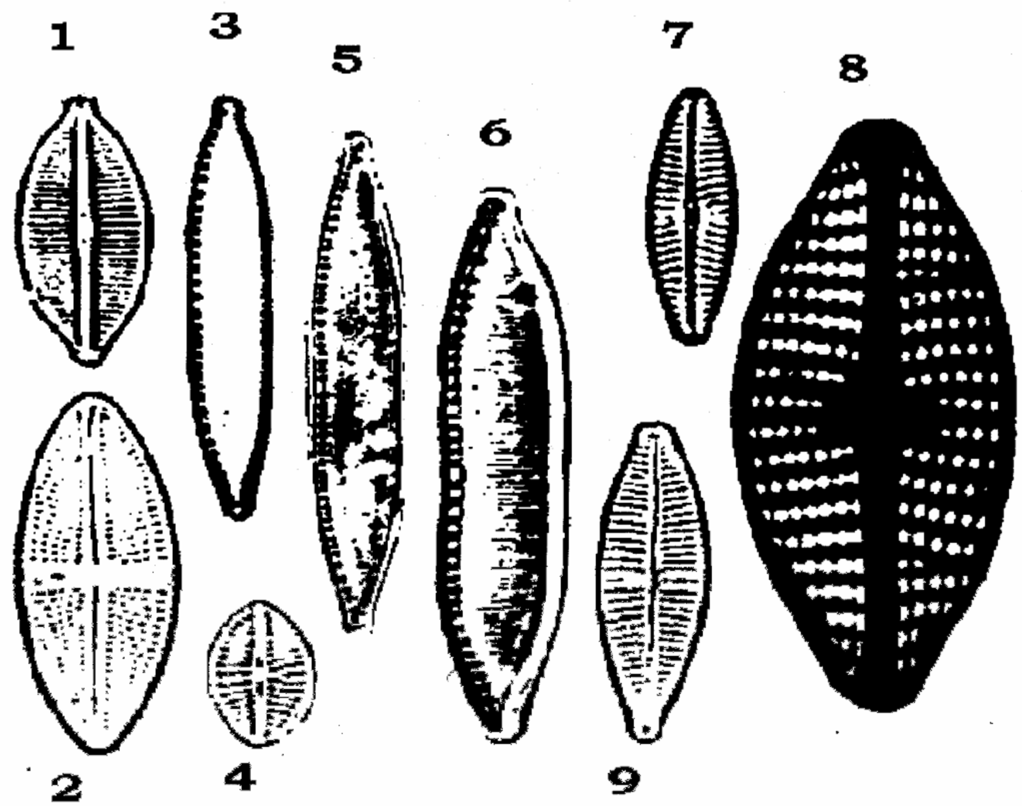
Tolerant Group of Species



1 Navicula gregaria (im TEM)....10 Nitzschia clausii
2 Navicula gregaria....................11 Fragilaria capucina
3 Navicula trivialis........................12 Fragilaria pulchella
4 Navicula lanceolata..................13 Achnanthes lanceolata
5 Nitzschia palacea.....................14 Achnanhtes lanceolata
6 Nitzschia supralitorea..............15 Suriella ovalis
7 Nitzschia supralitorea..............16 Cymbella silesiaca = ventricosa
8 Nitzschia hungarica..................17 Cymbella silesiaca = ventricosa
9 Nitzschia filiformis

FIGURE 3: RESISTANT GROUP OF DIATOM TAXA

Resistant Group of Species



1 Navicula accomodata
2 Navicula goeppertiana
3 Nitzschia palea
4 Navicula subminiscula
5 Nitzschia capitellata
6 Nitzschia umbonata
7 Navicula veneta
8 Navicula veneta (TEM)
9 Gomphonema parvulum

Stevenson et al (2001) developed a list of pollution-tolerant, pollution-sensitive, and phosphorus-sensitive diatom taxa as response indicators to environmental stressors in wetlands and marshes. Algae provide a temporally integrated indicator of environmental conditions (sensitive and precise responses to environmental change).

Additional Sensitive/Tolerant Algal Taxa (from Stevenson et al. 2001.):

I. POLLUTION-SENSITIVE
Achnanthes exigua
Achnanthes hustedtii
Achnanthes linearis
Achnanthes microcephala
Achnanthes minutissima
Amphora ovalis
Anomoeneis serians
Anomoeneis vitrea
Cymbella microcephala
Cymbella minuta
Navicula radiosa
Synedra rumpens
Cymbella lunata
Mastogloia smithii

II. POLLUTION- TOLERANT
Gomphonema parvulum
Navicula minima
Navicula viridula
Nitzschia amphibia
Nitzschia frustulum
Nitzschia palea
Oscillatoria
Rhopalodia gibba
Scenedesmus
Anabaena
Cosmarium
Lyngbya

III. PHOSPHORUS-SENSITIVE
Anabaena subcylindrica
Anomoeneis vitrea
Cymbella lunata
Cymbella minuta
Mastogloia smithii
Synechococcus cedrorum

The Stevenson list plus Figures 1-3 above can be used to determine if periphyton samples collected from streams are impacted or relatively clean depending on the diatom taxa assemblages identified to be present in those samples.

The River Continuum

The hydrologic, geologic and biologic components of a river continuum encompasses the entire watershed of that system from its headwaters (includes tributaries, contingent physiochemical processes, and biota) to its mouth. In most watershed systems the headwaters and tributaries are fed by either surface water runoff, wetlands discharges, industrial and water treatment effluent/discharges, outfall from lakes/ponds, and springs. Important aquatic components of watershed systems include macrophytes, amphibians, aquatic macroinvertebrates, fishes, turtles, mats of algae (filamentous algae), substrate-colonizing periphyton and the microscopic biota, i.e., diatoms, phytoplankton, etc. (modified from Vannote et al. 1980).

Figure 4: The River Continuum Concept Illustrating the Periphyton Role

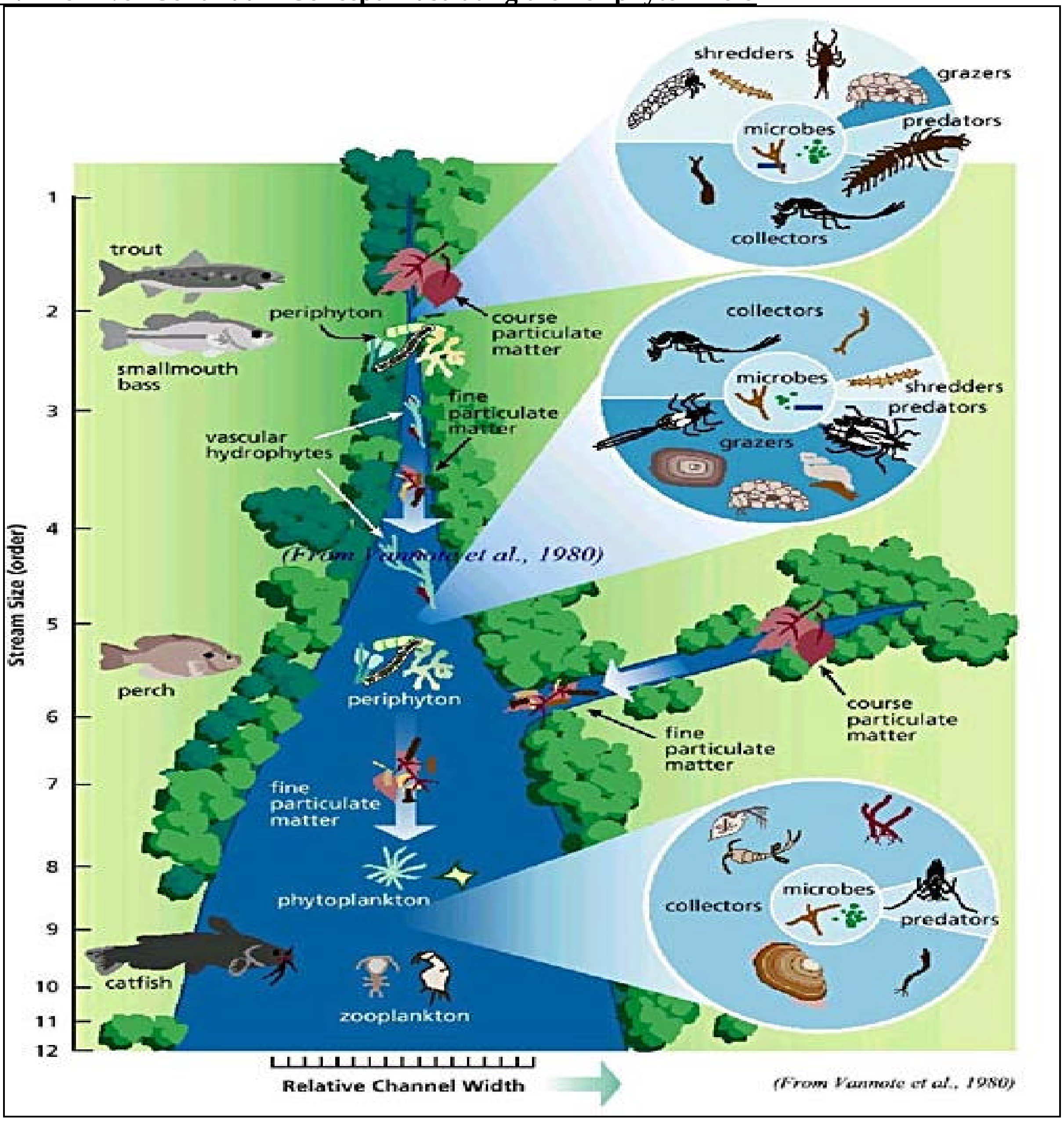


Figure 4 above illustrates the river continuum concept and the role that periphyton play as primary producers.

Periphyton respond rapidly and sometimes predictably to a wide range of pollutants and provide potentially useful early warning signals of deteriorating or impaired water quality conditions. Because of their position as primary producers at the base of aquatic food webs, algal indicators provide unique data concerning aquatic ecosystem health. Diatom communities are extremely sensitive to natural variations in abiotic factors, including current and nutrients (Medley & Clements 1998). It is well established that longitudinal variation in these and other physiochemical factors significantly influence benthic communities (Vannote et al. 1980). Headwater streams exhibit relatively small fluctuations in water chemistry and temperature, which are hypothesized to be important factors influencing benthic community structure. Species inhabiting headwater streams may be more susceptible to anthropogenic disturbance than species adapted to the fluctuating conditions in mid-order streams (Ward & Stanford 1983). Periphyton taxa from physically harsh environments possess traits that confer tolerance to both natural and anthropogenic disturbances; differences in water chemistry between upstream and downstream sites are reflected in changes in diatom community composition longitudinally. Diatom communities are sensitive bioindicators to a host of environmental variables that change along a stream's longitudinal gradient; physiochemical conditions constitute a general productivity gradient from upstream to downstream habitats, which influences ecological succession and produces later successional communities at downstream sites (Medley & Clements 1998). Therefore, one of the goals of the diatom sampling during 2006 is to determine the longitudinal variation in diatom taxa in the watersheds (EFPC, Bear Creek, White Oak Creek, and Mitchell Branch) on the ORR (see Maps 2 & 3). Also, see hypotheses section below.

Pollution (environmental insults) of an aquatic system comes in many forms including organic and inorganic chemicals, heavy metals, radiological contamination, microbiologicals, and those of a physical nature such as temperature, turbidity, and dissolved oxygen. Sources of pollution include industrial releases, agricultural runoff, and residential discharges. The complexity of modern day pollution complicates the clear delineation between tolerant, resistant, and sensitive species of diatoms (Patrick 1973). Data in the literature is lacking that associate certain diatom species with particular contaminants. Direct correlation between specific chemical contaminants and the presence/absence of diatom species are difficult to determine. However, by examining diatom community assemblages and studying shifts in species composition and structure over time, impaired water quality can be detected (Patrick, 1973). Being primary producers and on the base of the food web, diatoms are especially vulnerable to perturbations. Incorporating a diatom biological monitoring program permits an assessment of the ecological integrity or health of a stream (Hoffmeister 2000). The metrics outlined below in the methods and materials section will be used as analytical tools to evaluate the data generated from the field information gathered in 2006.

One of our target watersheds, East Fork Poplar Creek, has the presence of heavy metals in water and sediments which have been documented in various Y-12 Plant BMAP reports (Hinzman 1980). Historically high concentrations of mercury (Hg), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), and zinc (Zn) downstream of Y-12 plant discharges indicates a source or sources within Y-12 Plant boundaries. Mean surface water sampling results from EFPC show a trend towards decreasing metal concentrations downstream of the Y-12 Plant. The two sites closest to possible sources, EFK 24.4 and EFK 23.4 had mercury levels greater than two times those measured at EFK 13.8 and EFK 6.3. Zinc also showed decreasing concentrations with distance longitudinally downstream with a moderate increase at EFK 6.3 (Hoffmeister 2000).

Numerous studies have been conducted on the species and community levels showing the effects of metals on diatoms (Deniseger et al. 1986, Takamura et al. 1989, Kelly et al. 1995, Peres et al. 1997, Medley & Clements 1998). The trend toward increasing diatom species richness with distance longitudinally downstream suggests a correlation with the decrease in metal concentrations within EFPC. Medley & Clements (1998) observed similar trends of increasing richness with distance longitudinally in metal-contaminated streams.

Studies by Deniseger et al. (1986) and Takamura et al. (1989) indicate that *Achnanthes minutissima* has a tolerance for metals and tends to be the dominant species in streams that have metal impacts. A laboratory study by Pérès et al. (1997) showed that *A. minutissima* was able to tolerate high concentrations of organic mercury (MeHg) in the water column and sediments. This is a significant observation since the methylated form of mercury has a far more toxic effect on the structure, function, and abundance of a diatom than the inorganic elemental form (Peres et al., 1997). The tolerance of *A. minutissima* to high metal concentrations is evident in the high disturbance index at EFK 23.4. *A. minutissima* was absent in the sample collected from the most distant EFPC site, EFK 6.3 as well as the reference site, Hinds Creek. An apparent relationship exists in EFPC where diatom species richness increases with distance downstream longitudinally in accord with a decline in metal concentrations. The degrees of siltation and relative disturbance decrease in EFPC as distance increases from the Y-12 Plan (Hoffmeister 2000).

For the reasons just outlined, East Fork Poplar Creek, Bear Creek and White Oak watersheds will be sampled on a monthly basis and the reference sites will also be sampled monthly for an additional year to provide periphyton community structure data for all seasons.

Hypotheses:

(1) It is expected periphyton samples collected from reference streams (Mill Branch, Brushy Fork, Upper White Oak Creek, and Hinds Creek) will exhibit superior taxonomic diversity (composition) and abundance than samples collected from the impaired waters of East Fork Poplar Creek, Bear Creek, and White Oak Creek.

(2) It is hypothesized diatom diversity and composition will improve in East Fork Poplar and Bear Creeks with distance longitudinally downstream from the upstream (headwaters) origin of contamination associated with the Y-12 National Security Complex.

(3) It is predicted that certain diatom species are tolerant of contaminated aquatic environments, and will have adapted to these conditions, and may dominate the taxa assemblage collected from artificial substrates at these locations.

(4) It is predicted that determination of diatom community structure will serve as an additional bioindicator of water quality supporting macroinvertebrate and fish sampling.

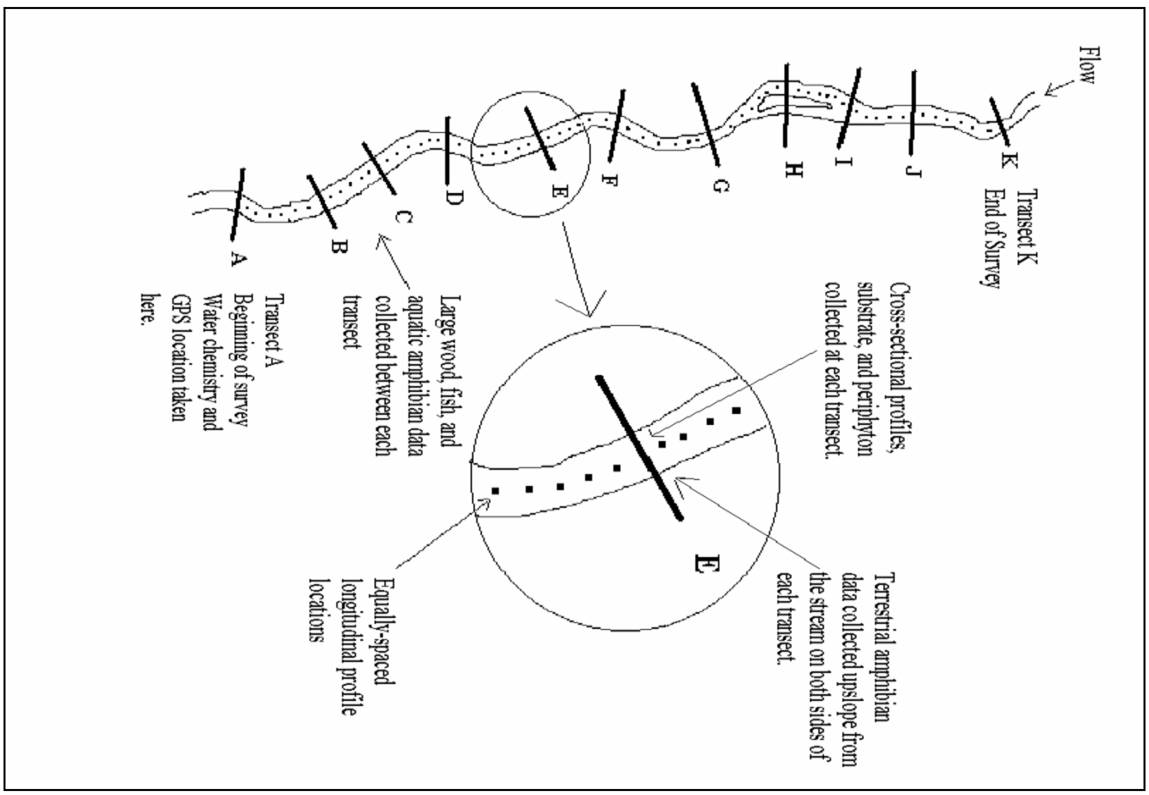
Methods and Materials

EMC proposes to sample periphyton at eighteen (18) stream riffle zone sites in 2006 within the East Fork Poplar Creek (EFK), Bear Creek (BCK), White Oak Creek (WCK), and Mitchell Branch (MIK) watersheds including associated reference sites. Specific site locations in stream kilometers (miles) and respective reference sites include (see Maps 1-3):

East Fork Poplar Creek: EFK 24.4 (15.2), EFK 23.4 (14.5), EFK 13.8 (8.6), and EFK 6.3 (3.9). Reference site: Brushy Fork / BFK 7.6 (4.7) and/or Hinds Creek / HCK 20.6 (12.8)
Bear Creek: BCK 12.3 (7.6) and BCK 10.3 (6.4). Reference site: Gum Hollow Branch /GHK 2.9 (1.8) and/or Mill Branch / MBK 1.6 (1.0)
White Oak Creek: WCK 3.9 (2.4), WCK 2.9(1.8), WCK 2.3 (1.4), and Melton Branch / MEK 0.3 (0.2). Reference site: WCK 6.8 (4.2)
Mitchell Branch: MIK 0.71 (0.44), and MIK 0.45 (0.28). Reference site: MIK 1.43 (0.89)

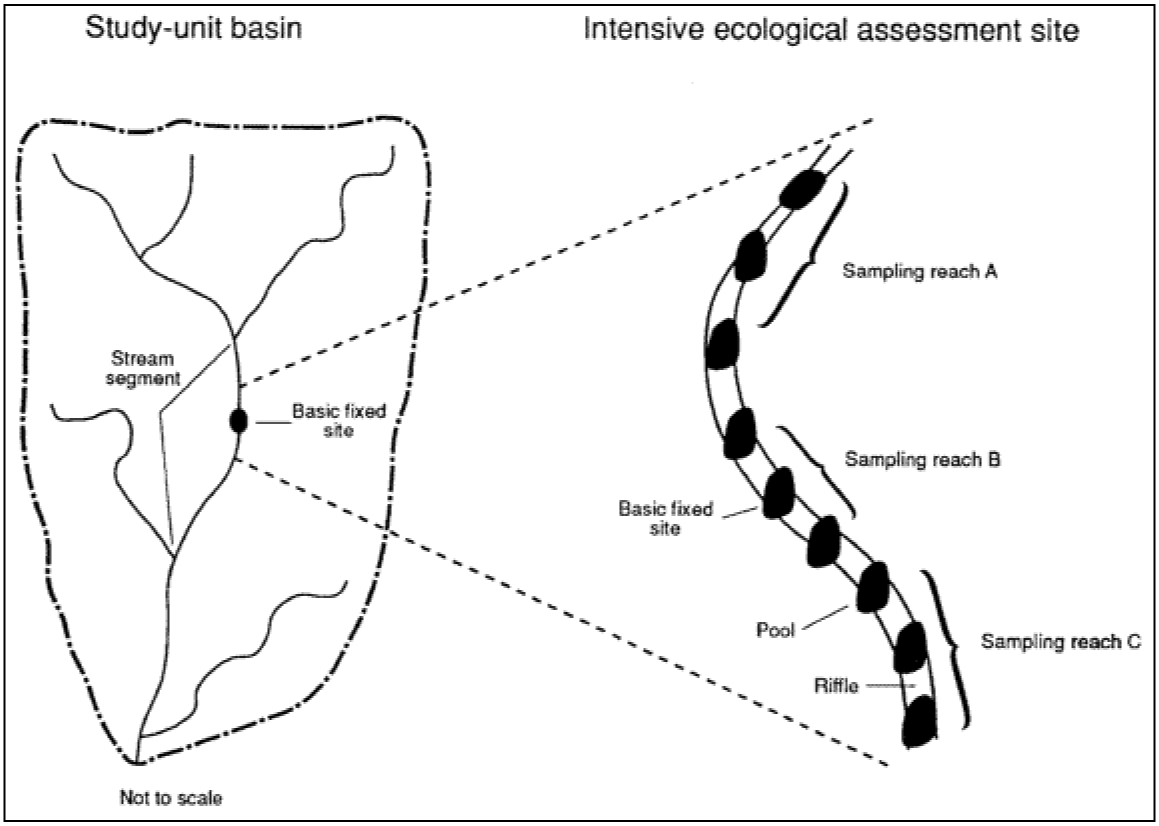
Field methods and protocols to be employed during this project will adhere to the U.S. EPA "Periphyton Sampling Protocol" (Barbour et al. 1999), also the U.S. EPA's "Environmental Monitoring and Assessment Program – Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams," (Peck et al., 1999), and the USGS "Methods for Collecting Algal Samples as Part of the National Water Quality Assessment Program" (Porter et al. 1993). Figures 5 and 5-A are example schematics of possible stream transects and sampling reaches (riffles) based on protocols of the Northwest Indian Fisheries Commission and the USGS.

Figure 5 - Hypothetical Stream Sampling Profile:



Source: Field Protocol Synopsis: Aquatic & Riparian Effectiveness Monitoring Program for the Northwest Forest Plan – Pilot Year 2001 http://www.nwifc.wa.gov/SAGE/metadata/aquatic/2001protocol-forest-plan-surveys.doc

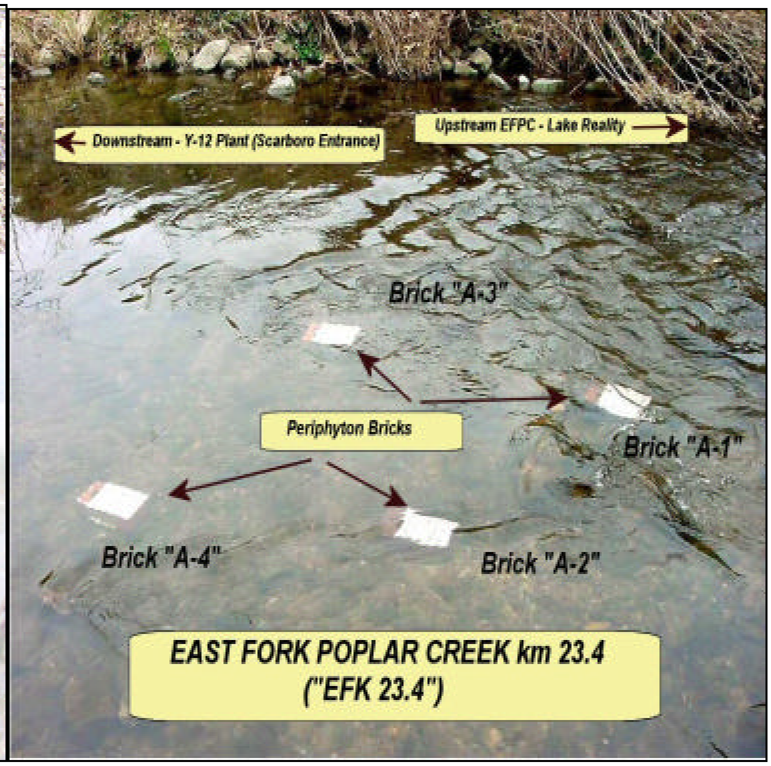
Figure 5-A: Hypothetical Location of a Basic Fixed Site and Associated Sampling Reaches for Ecological Assessments:



(Source: Porter et al. 1993)

EMC personnel will employ artificial substrates (i.e. "periphytometers") composed of standard red bricks and unglazed 2 x 2 inch (or smaller 5.76 cm2) ceramic tiles (attached w/silicon glue) to provide a surface for diatom colonization, or we may use a combination of artificial substrate and natural substrate sampling (the protocol for natural substrate sampling is detailed below in the methods section). Three (3) bricks will be deployed (spaced about 2 feet apart) at each site to allow colonization in various watershed habitats. Figure 7 is a digital camera image of a deployment of periphytometers used in an East Fork Poplar Creek independent project during early 2004. Each of the periphytometers will have an identification number affixed while deployed in the field to prevent confusion and mix-ups while collecting samples. The periphytometers will be installed at all locations by March 2006, and will be stabilized to the substrate using 12 inch rebar; the periphytometers will be submerged approximately 6-18 inches deep along unshaded riffle zones wherever possible. The artificial substrates will be left instream and samples collected for a period of one year. This method will provide periphyton colonization data to be collected during the four seasons. Figure 6 is a digital camera image of a well-colonized brick after being deployed for several weeks. About once a week each site will be inspected to check the integrity of the substrates and to clear debris that may have collected around the periphytometers (which would impair photosynthesis and algae colonization).

New data to be collected during 2006 will be the determination of light data measurements using a LI-COR™ LI-250A light meter/radiation "quantum sensor" (for determination of both above the surface of the water and submerged readings). In benthic algae, light is a fundamental variable which allows algae to photosynthesize inorganic compounds into living biomass (Hill 1996). Since photosynthesis responds quantitatively to changes in light (irradiance), environmental variation (shading variation due to percent canopy cover, etc.) in its quantity and quality potentially accounts for much of the variation in the physiology, population growth, and community structure of benthic algae (Hill 1996). Photosynthesis is restricted to wavelengths of 400-700 nm, a range of wavelengths termed photosynthetically active radiation, or "PAR" (Hill 1996), and the chlorophyll pigments "a" and "c" plus the carotenoid pigment fucoxanthin, contained in most diatom chloroplasts, falls within this measurable range. The radiation in this range, referred to as "PAR," can be measured in energy units (watts $^{m-}$2), or as Photosynthetic Photon Flux Density (PPFD), which has units of quanta (photons) per unit time per unit surface area. The units most commonly used and recorded in the field with the LI-COR™ equipment are micro-moles of quanta per second per square meter (umol s^{-1} m^{-2}). Field data collected with the LI-COR™ light meter/quantum sensor will be valuable information and important as a variable parameter in addition to collecting pH, temperature, conductivity, dissolved oxygen, and other water chemistry-type data.



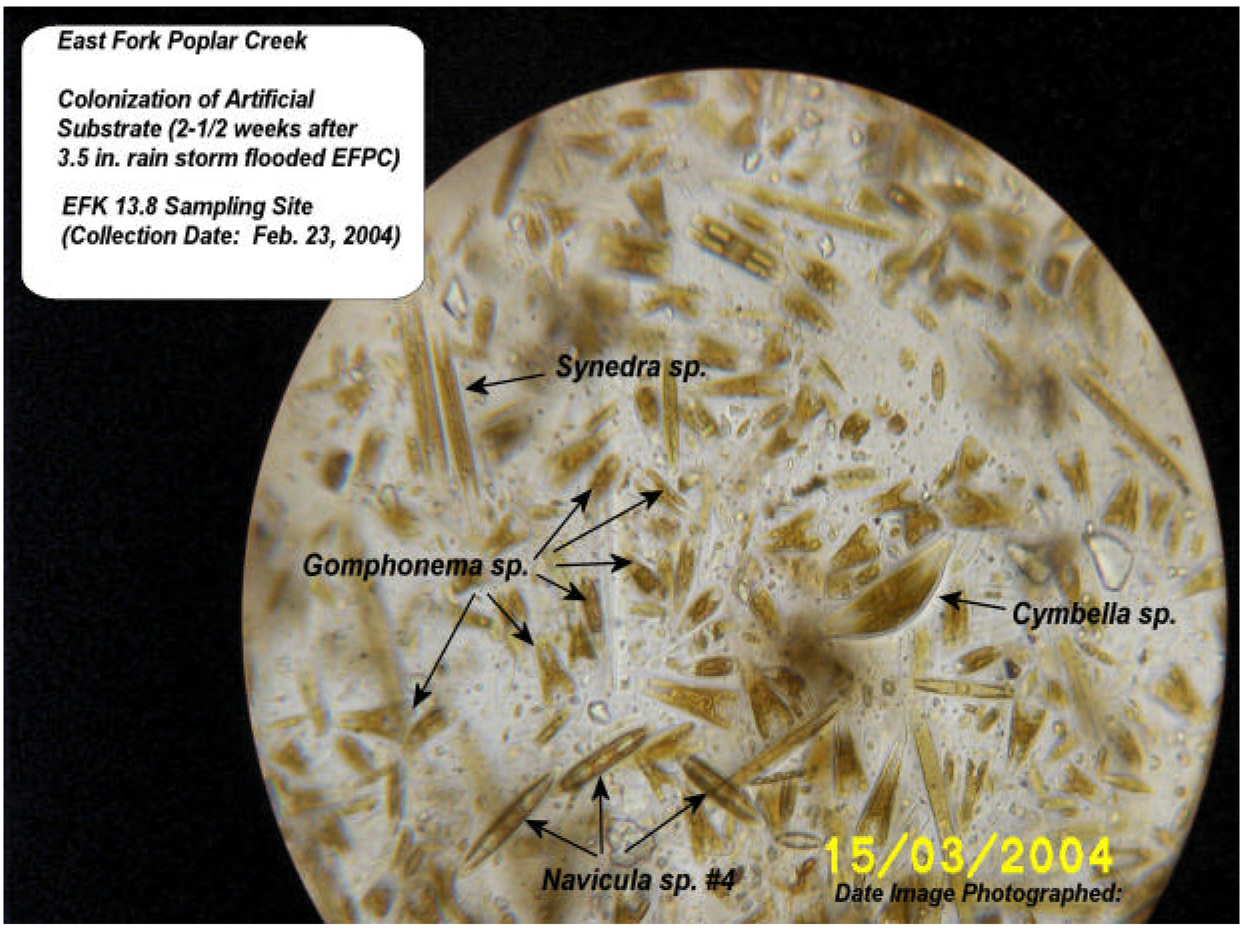
Images made with a Kodak DX3700 EasyShare™ digital camera (RGM photos).

Figure 6: Colonized Brick **Figure 7: Brick (Periphytometer) Deployment**

Diatom samples will be collected at the EFPC sites on a monthly basis; the Mitchell Branch, Bear Creek & White Oak Creek/Melton Branch sites will be sampled monthly also. The reference sites (Brushy Fork/BFK 7.6, Hinds Creek/HCK 20.6, Gum Hollow/GHK 2.9, Mill Branch/ MBK 1.6, WCK 6.8, & MIK 1.43) will be sampled every four weeks. Physical parameters including water depth, stream flow, and percent canopy will be measured at each artificial substrate location and recorded in the field logbook. Water temperature, conductivity, total dissolved oxygen and pH measurements will also be determined during each sampling event (using the Horiba U-10™ Water Quality Checker). The periphytometer setup at EFK 23.4 will employ an artificial shading system of plexiglass plates suspended over the bricks to simulate different canopy densities and photosynthetic effects of such cover.

Once samples are brought back to the laboratory, they will be preserved will Lugol's solution, and refrigerated. Then, the task of taxonomic identification of the diatoms begins by first making a cursory inspection of the freshly preserved sample by placing a 0.5 mil aliquot on a glass slide with coverslip, and observing fields-of-view at high magnification (400-800x power). Then, permanent mount slides will be prepared per the acid bath method outlined below to clean the diatoms of all organic material leaving only the glass frustules. Then, the permanent slides can be viewed at high magnification and taxonomic determinations completed. Figure 8 is a digital camera image of a microscopic field-of-view of a fresh periphyton sample, and then, Figure 9 shows a field-of-view of a permanent slide mount representing a periphyton sample that has been cleaned of organic material in an acid bath, then a permanent mount prepared of the remaining diatom frustules.

<u>Figure 8: Fresh (Uncleaned) Periphyton Sample (~400x magnification):</u>

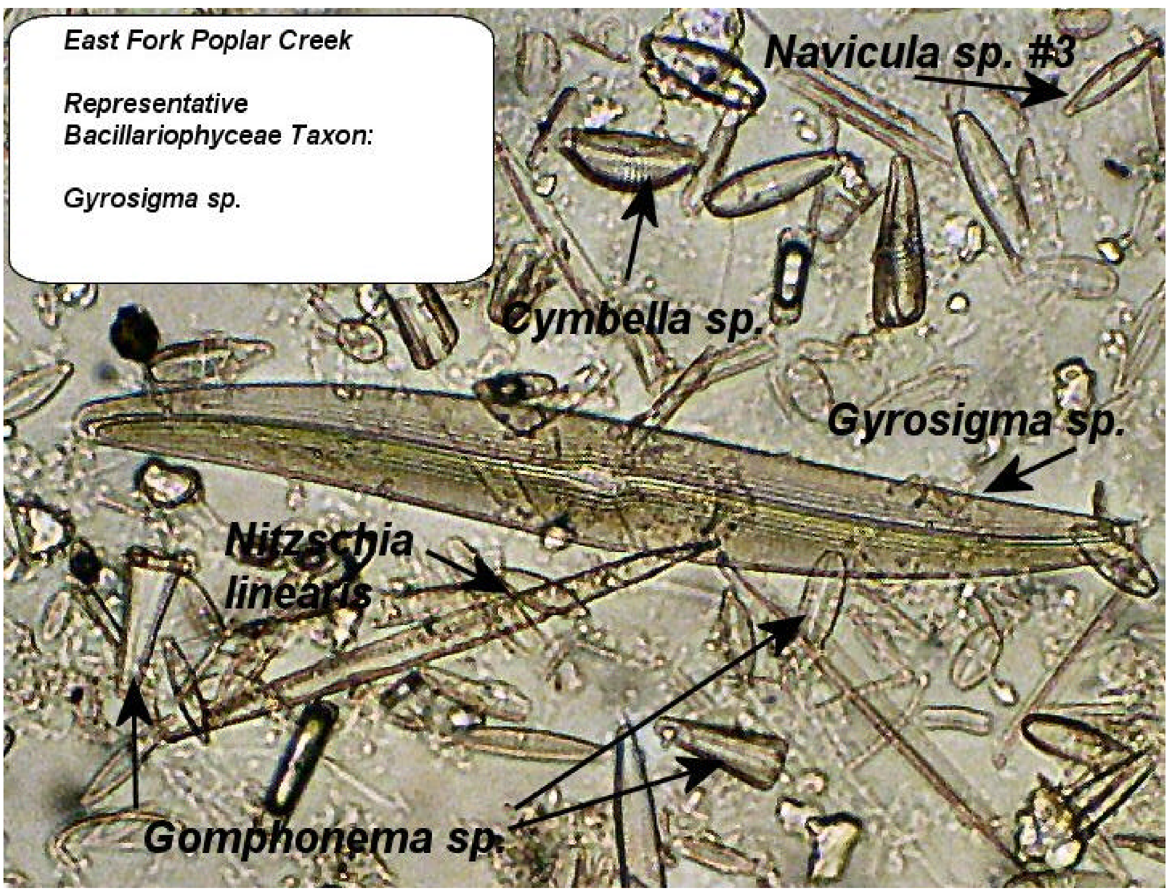


Images made with a Kodak DX3700 EasyShare™ digital camera (RGM photos).

Water quality** samples will be collected semiannually in support of the periphyton sampling and monitoring. The diatom sampling event schedule will occur every 1-4 weeks (for +/- 50 weeks), thus allowing adequate time for diatom colonization. Then, artificial substrates will be retrieved and tiles containing representative assemblages of diatom communities will be scraped or brushed, and algae sample slurry carefully collected into labeled plastic vials (brown). See Figures 10-13 for sampling/sample preparation methods. The diatom sample slurry removed from the tiles will be preserved with Lugol's solution. The initial slurry volume of each sample will be carefully measured in a laboratory graduated cylinder and recorded in the log book. Internal and external labels with site specific collection information will be included with each sample container. Digital photographs will be obtained of all 18 sample stations for future reference. The diatom samples will be packed in ice and transported to the TDEC-DOE-O laboratory and stored in a refrigerator for future sample processing. During each sampling event, the artificial substrates will be removed from the sampling sites and replaced with fresh artificial substrates for the next colonization time period. All project activities will adhere to the DOE Oversight Division's Health, Safety, and Security Plan (TDEC, 2005).

**Water quality parameters: (1) metals (As, Cd, Ca, Cr, Co, Fe, Hg, Pb, Mg, Mn, Ni, K, Se, Na, Tl, Zn), (2) alkalinity, total, as CaCO3, (3) pH, conductivity, (4) E. coli, Enterococcus, ammonia, NO3 & NO2 nitrogen, total kjeldahl nitrogen, total phosphate, (5) radiological (gross alpha, gross beta, gamma radionuclides), and (6) dissolved residue, suspended residue, COD, etc.

Figure 9: Cleaned Periphyton Sample / Permanent Slide Mount (~800x magnification)



Images made with a Kodak DX3700 EasyShare™ digital camera (RGM photos).

Duplicate samples will be collected at 10% of the sites for Quality Assurance/Quality Control (QA/QC) purposes. Percent Community Similarity (PCS) will be computed between the study site sample and the QC sample for that site. PCS will assess the similarity between the estimated densities of diatom species shared in both samples. These laboratory QA/QC procedures adhere to EPA methods for assessing periphyton communities in lotic systems (EPA, 1998).

All samples will be examined "in-house" by EMC staff using the Olympus™ BH-1 Stereo microscope and the Zeiss™ inverted microscope (on loan from ORNL ESD). Laboratory analysis will involve taxonomic identification and enumeration of diatom species for each sampling site. Identifications will be attempted on both fresh sample material and cleaned diatoms. Standard Operating Procedures to be employed by EMC staff will involve "cleaning" the diatoms (boiling acid bath), permanently mounting the diatoms on microscope slides, and identifying specimens to the generic or species level until 30 microscope fields have been examined or 300 cell counts made. The laboratory method for cleaning and mounting diatom slides is detailed below. EMC staff will maintain bench sheets for recording all microscopic taxonomy data. QA/QC laboratory procedures will be implemented according to the TDEC DOE-O laboratory standard operating procedure. Reference digital camera photographs will be taken of most diatom taxa during microscopic analysis for future reference and to document taxonomic identifications for verification purposes. EMC personnel will implement QA/QC procedures on the diatom slides to ensure accuracy and completeness of identifications. Any discrepancies will be reconciled and, if necessary, bench data sheets will be corrected. If possible, every six months, one sample from each site will be sent to an outside contractor for taxonomic QA/QC purposes (during the 1997-2000 diatom sampling project, Pennington and Associates, Cookeville, Tennessee was awarded a contract to do the taxonomy and metrics on the algae samples). The data and information generated by this project will be used to meet the objectives as defined in the introduction and to form a database for calculating the metrics. An archive of digital camera microscope field-of-view images of diatoms will be saved on a recordable compact disk (CD-rom) for future reference and verification of taxonomic determinations. This photographic method will represent a diatom record analogous to herbarium sheets of terrestrial plants used in systematic botany.

Methodology and Protocol Specifics:

I. Cleaning of Diatom Frustules (per Hill 2004):

(1) Aliquots of preserved periphyton sample slurry (approx. 2ml) will be withdrawn from each sample container and placed in a 100 ml flask; then 10 ml of hydrochloric acid (1N) will be added and heated on a hotplate (under a fume hood) to boiling for about 1 hour or until approximately 1-2 ml's of liquid remained. Then, 20 ml aliquots of deionized water will be added, the mixture blended, cetrifuged, and decanted until approximately 5 ml of cleaned periphyton slurry remain.

(2) Permanent slide mounts will be prepared by placing a drop of well mixed slurry onto a cover slip, then gently dried on a hotplate (at low temperature). Next a few drops of Naphrax mounting medium will be placed on the slide, then a glass coverslip will be carefully placed ("hinge-gate dropped") with the dried sample face down on the coverslip with the Naphrax.

Then the slide will be placed on the hotplate again until the toluene in the Naprhax has slowing evaporated leaving a nice permanent mount. The purpose of the Naphrax is that the finished slides now have a high refractive index for superior microscope viewing of the diatom frustule morphology (upon which the diatom keys are contingent). Figure 9 above is an excellent example of a microscopic view of a permanent mount slide prepared in this manner.

II. Field Equipment for Periphyton Sampling--Natural Substrates +

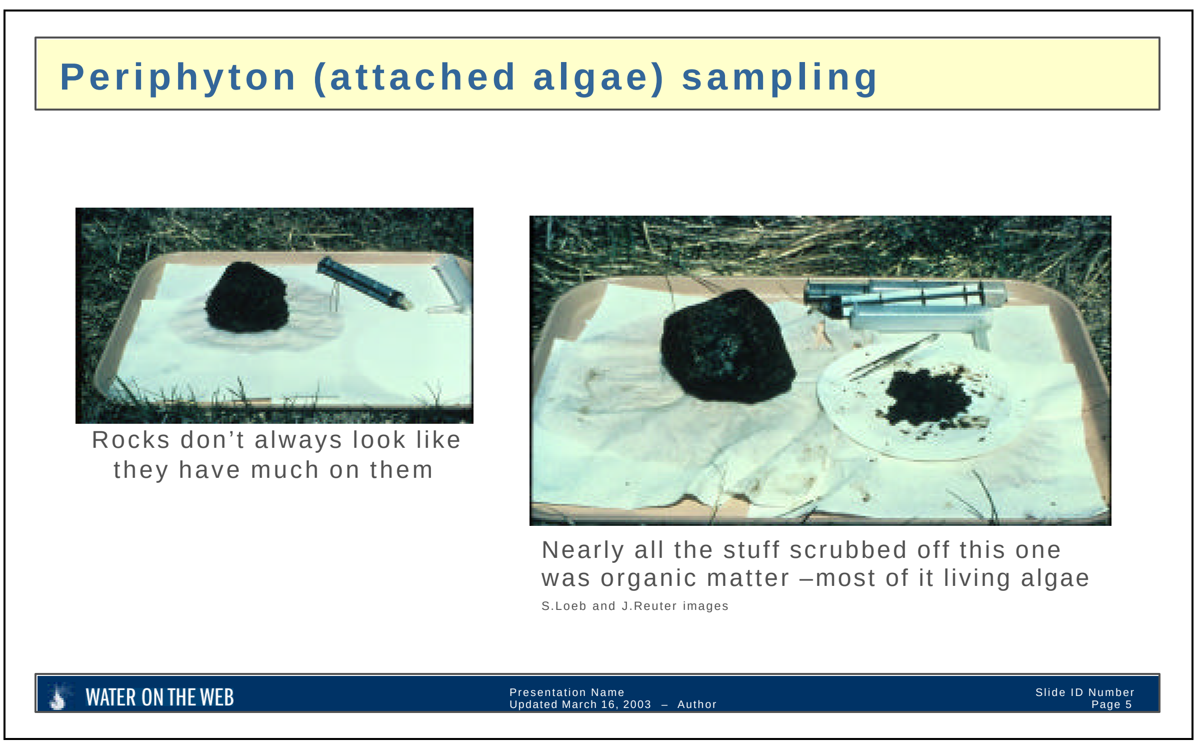
stainless steel teaspoon, toothbrush, or similar brushing and scraping tools
section of PVC pipe (3" diameter or larger) fitted with a rubber collar at one end
field notebook or field forms*; pens and pencils
white plastic or enamel pan
Horiba™ U-10 Water Quality Checker
Flow Rate Meter
petri dish and spatula (for collecting soft sediment)
forceps, suction bulb, and disposable pipettes
squeeze bottle with distilled water
sample containers (125 ml wide-mouth jars) ; brown/amber 28 mil plastic bottles
LI-COR™ Light Meter/Sensor
preservative [Lugol's solution, 4% buffered formalin, "M3" fixative, or 2% glutaraldehyde (APHA 1995)]
first aid kit
cooler with ice

* During wet weather conditions, waterproof paper is useful or copies of field forms can be stored in a metal storage box (attached to a clip-board). + source: Stevenson & Bahls 1993.

Figure 10: Examples of Periphyton Natural Substrate Sampling Equipment:

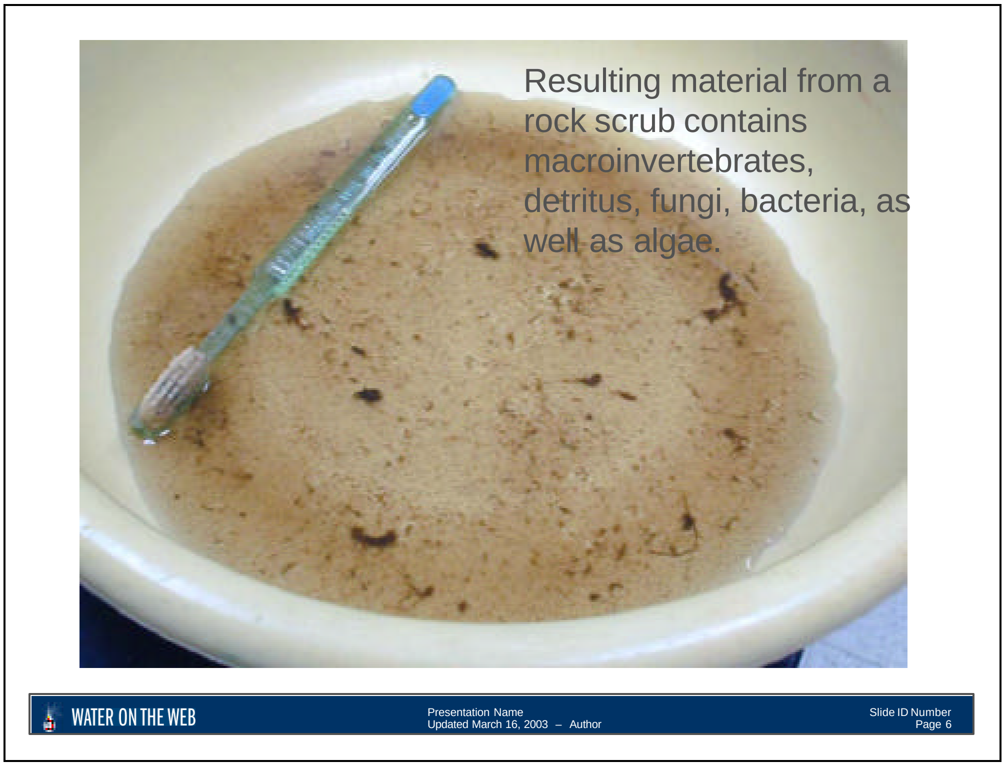
Sourc
e: Bouchard & Anderson, Kansas Biological Survey, unpublished draft.

Figure 11: Periphyton Sample Retrieval from Natural Substrate by Scraping (Field Method):



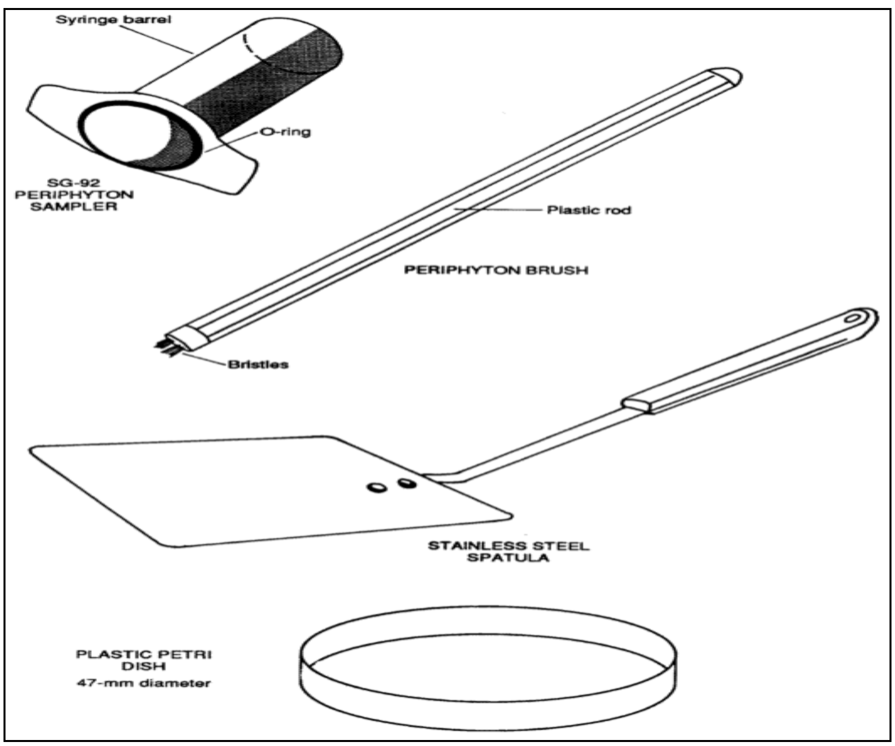
(Source = Water on the Web, 2003)

Figure 12: Periphyton Sample Slurry Removed from Natural Substrate by Brushing



(Source = Water on the Web, 2003)

Figure 13: Diagrams of Quantitative Periphyton Sampling Equipment:



(Periphyton "SG-92" Sampler) Porter et al 1993.

Quantitative periphyton samples are collected by removing attached algae (from rock substrate) contained within the circular sampling area of the SG-92 sampler with a periphyton brush. The SG-92 is firmly seated to a desired flat substrate surface by pressing the O-ring of the SG-92 assembly firmly against the rock and rotating the assembly approximately ¼ turn before dislodging periphyton with the brush. The area (of the sample surface) of the SG-92 is typically 2.5-3.1 cm2. The algae-water (slurry) mixture is withdrawn from the SG-92 with a 5-ml hand pipettor and placed into a labeled sample container. Stream water is then added to the SG-92, and the procedure is repeated until all algal biomass has been removed from the surface sampling area and collected into the sample container (Porter et al. 1993).

<u>III.</u> <u>Metrics:</u>

A. Analysis of the data collected in 2006 will include a measure of species richness and density, species diversity (Shannon), and evenness (Pielou) among the species for each site. Percent community similarity will be computed between sites to ascertain the similarity between the estimated densities of diatom species shared at the sites. The aforementioned metric applications are used by the Kentucky Department of Environmental Protection (DEP) and the Florida Department of Environmental Protection (DEP) for periphyton data analysis (EPA, 1998).

Additional metrics that may be utilized in addition to <u>or in lieu of</u> the above metrics include:

B. "DBI" = Diatom Bioassessment Index (per Brumley et al. 2004): The DBI is a multi-metric index that uses 6 diatom community structure metrics. It is intrinsically designed to be sensitive to nutrient enrichment, as well as other insults including sedimentation salinity, acidity, and metals. Diatom indicators of environmental conditions can be more precise than one-time sampling and assessments of water chemistry.

(1) Total Number of Diatom Taxa (TNDT) = total number of taxa identified (those counted & those showing up on the scan of the slide) and is an estimate of diatom taxa richness
(2) Shannon Diversity
(3) Pollution Tolerance Index (PTI) = each taxa is assigned a tolerance value based on their tolerance to increased pollution; tolerance values range from 1 (most tolerant) to 4 (most sensitive); Figures 1-3 could be used for this metric.
(4) *Cymbella* Group Richness (CGR) = Total number of taxa from the following genera: *Cymbella*, *Cymbopleura*, *Encyonema*, *Encyonemopsis*, *Navicella*, *Pseudoencyonema*, & *Reimeria*
(5) *Fragilaria* Group Richness (FGR) = Total number of taxa from the following genera: *Ctenophora*, *Fragilaria*, *Fragilariforma*, *Pseudostaurosira*, *Punctastriata*, *Stauroforma*, *Staurosira*, *Staurosirella*, *Synedra*, & *Tabularia*
(6) % *Navicula*, *Nitzschia*, *Sururella* (%NNS) = The sum of the relative abundances of all *Navicula*, *Nitzschia*, & *Surirella* taxa

According to Brumley et al. (2001), for scoring the DBI, each metric is standardized to the 95th percentile of the reference distribution; each metric score is based on a 100 point scale. Divide the metric score by the 95th% * 100; the total DBI score is the mean of the 6 metric scores. If a metric score falls above the 95th percentile, then a score of 100 is given. DBI scores and criteria are used, in conjunction with macroinvertebrates and fish, for site assessment purposes. Diatom taxa can infer stressors involved in lowering the biological integrity of a site. All three assemblages (diatom, macroinvertebrate, and fish) are weighted equally when conducting a bioassessment of a site. For each assemblage, a narrative rating (excellent-very poor) is derived from each index score. A numeric score is then assigned based upon the narrative rating (5 = excellent and 1 = very poor). Finally, an average score is calculated to obtain an overall numeric rating for the site.

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CHAPTER 2 BIOLOGICAL/FISH AND WILDLIFE

Canada Geese Monitoring Plan

Introduction

A large population of Canada geese, both resident and transient, visits the Oak Ridge Reservation (ORR). While migratory geese have always visited East Tennessee, Tennessee Valley Authority (TVA) and Tennessee Wildlife Resources Agency (TWRA) introduced the resident population to the Melton Hill region in 1972. Geese prefer to eat grass, but will also eat water plants including root nodules from bottom sediment. Studies in the 1980s demonstrated that geese associated with the contaminated ponds/lakes on the ORR can accumulate radioactive contaminants quickly and that contaminated geese frequent off site locations. The thriving goose population in this area makes this animal an easily accessible food for area residents. Although hunters are offered the opportunity for a radiological screening of their kills, not many take advantage of this service (TWRA, personnel communication). Results of Tennessee Department of Environment and Conservation Department of Energy Oversight Division (the division) off-site sampling in 1999 showed no elevated levels of radioactivity in the geese sampled. Similarly, all geese captured during the Department of Energy (DOE) 1999, 2000, and 2001 "goose roundup" were below the 5 pCi/g game confiscation level, which DOE Oak Ridge has set as an administrative guideline. During the 2002 "goose roundup," three geese were captured from ONRL that had Cs-137 levels above the 5 pCi/g game confiscation level. Geese subsequently captured in offsite sampling at the Oak Ridge Marina showed no Cs-137 or other contamination above the confiscation level. During the 2004 "goose roundup," all geese sampled were below the 5 pCi/g game confiscation level.

Geese with elevated levels of Cs-137 in muscle tissue have been found primarily in areas near ORNL. A study in September 1998 found elevated levels of Cs-137 in grass and sediment at two reaches of White Oak Creek south of 3513 Pond and in grass around the 3524 pond. Sediment in and around White Oak Lake (WOL) and White Oak Creek has elevated levels of Cs-137. Canada geese have been observed on WOL and throughout the ORNL area. After a flock of radioactive geese was found at ORNL in 1998, DOE took several measures to discourage the geese from using and feeding in contaminated areas. Flagging and fencing were improved and several areas were defoliated. These measures appear to have been successful, with no significantly contaminated geese being captured on or off the reservation in 1999 through 2001. State geese sampling would only take place, if any of the geese captured in the Year 2006 DOE "goose roundup" show significantly elevated levels of radioactivity (above 5 pCi/g). This would indicate the possibility of radioactively contaminated geese leaving the reservation.

Methods and Materials

During the week preceding the goose roundup, areas around the perimeters of the ORR will be scouted to identify locations of possible populations of geese. This will facilitate activities on the day of collection by predetermining likely locations to sample.

Sampling would take place immediately after the annual *ORR Goose Roundup* with equipment and assistance from TWRA and ORNL. Geese are molting at this time of year and are nearly flightless. Sampling would take place over a one to two day period. Variables such as flock location and ease of capture will affect the schedule.

The site selected should be near contaminated vegetation, water, and sediment. An optimum site is the Jones Island area in Loudon County. Geese from this area have access to White Oak Lake and other contaminated ORNL sites. Due to recent movements of populations, the most likely locations will be the Oak Ridge Marina and the Solway Park areas.

Geese would be captured using the same technique as the DOE goose roundup. Eight to fifteen people would slowly converge on a flock of geese forcing them into a temporary enclosure consisting of chicken wire and reinforcing bar. At least 15 individual geese would be captured to assure accuracy of the reading and a representative sample of the flock. Geese would be transported in cages to the TWRA check station for weighing, sexing, and a whole body count. All activities would be carried out in compliance with the division's Health, Safety, and Security Plan (2004).

Results of the whole body count would determine the necessity for further analysis of the geese. If the whole body counts showed the radioactive contamination of the geese to be 5 pCi/g or greater, muscle tissue from the contaminated geese will be radiologically analyzed to confirm the results of the whole body counts and to determine if other contaminants are present. Additional analyses would be for cesium-137, mercury, cadmium, selenium, and lead in the breast and/or leg tissue of geese with whole body counts above 5 pCi/g. Up to six geese (two high, two medium, and two low whole body counts) would be analyzed from a contaminated flock.

Most material will be provided by TWRA. This includes:

- Fencing
- Cages
- Tags

The whole body counters are the property of ORNL and would be operated by their personnel.

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Chapter 2 BIOLOGICAL/FISH AND WILDLIFE

Monitoring and Sampling of Aquatic and Terrestrial Plants in Surface Water and Ecological Habitats on the ORR

Introduction

The gathering of collateral information in support of the division's groundwater monitoring and sampling efforts of springs and surface water will be a priority of this project. If surface water bodies (i.e., springs, ponds) have been impacted by hazardous substances, it is likely that the aquatic plant organisms in the immediate vicinity could be uptaking radionuclides or other hazardous substances. The focus of this plan/program will be the detection and characterization of hazardous substances bioaccumulated by both aquatic and terrestrial vegetation to determine ecological and human health risk factors.

Target vegetation examples for sampling will include (but not be limited to): 1) watercress; 2) green algae (*Ulothrix, Spirogyra, Oedogonium,* etc.); 3) periphyton (benthic algae -see discussion below); 4) mosses (Bryophyta); 5) liverworts (Hepatophyta); 6) horsetail and quillworts (*Equisetum and Isoetes*); 7) floating & attached aquatic plants (*Azolla, Lemna, Wolffia, Salvinia*); 8) club moss (*Huperzia sp*.); and 9) lichens (*Cladina sp.* and *Cladonia sp.)*. These plant species have been selected because they are excellent bioindicators. These plants are remarkably sensitive to pollution, radioactive fallout, and other hazardous substances (pathogens, i.e., chemicals, metals, etc.). These plants are known to be ingested by aquatic organisms and herbivores.

Watercress, a floating, rooted, aquatic plant (angiosperm) has been selected for its affinity to thrive around its natural habitat, in clear slow-moving water near the mouth of springs. If the spring water is impacted, then aquatic plant species are likely to have absorbed some of the hazardous substances.

Green algae and "periphyton" occur in most of the aqueous environments within ORR watersheds (Upper East Fork Poplar Creek). Periphyton is a term used to describe communities of microorganisms that are attached to various aquatic substrates and grow as thick gelatinous mats of mixed assemblages including green algae, cyanobacteria, fungi, associated macrophytes (e.g., cattails, duckweed, water spangles, etc.), invertebrate grazers (e.g., snails), and detritus. Periphyton biomass produces much of the low end of the food chain for many aquatic organisms and herbivores. They are sensitive indicators of environmental physiochemical change and bioaccumulation of hazardous substances.

Prospective habitats both on and off-site of the ORR such as springs, seeps, karst features, streams, wetlands, impoundments (ponds), landfills, creek embankments, rock outcrops, state Natural Areas, and other terrestrial ecosystems will receive priority as potential sampling and monitoring sites (see Figures 1 and 2). Watersheds such as Bear Creek and its tributaries, White Oak Creek/Lake and its tributaries, and Mitchell Branch are all probable target habitats for sampling.

Figure 1: Potential Aquatic Plant Sampling Locations - East Half of ORR

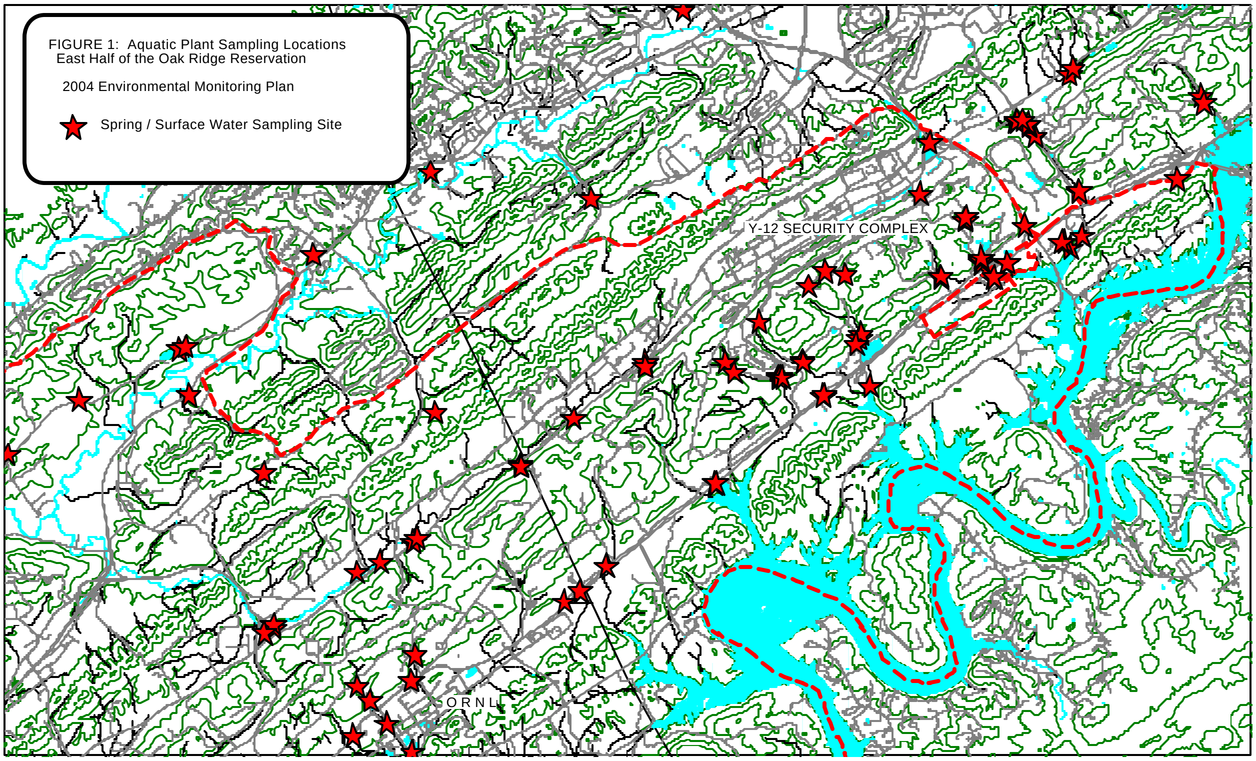
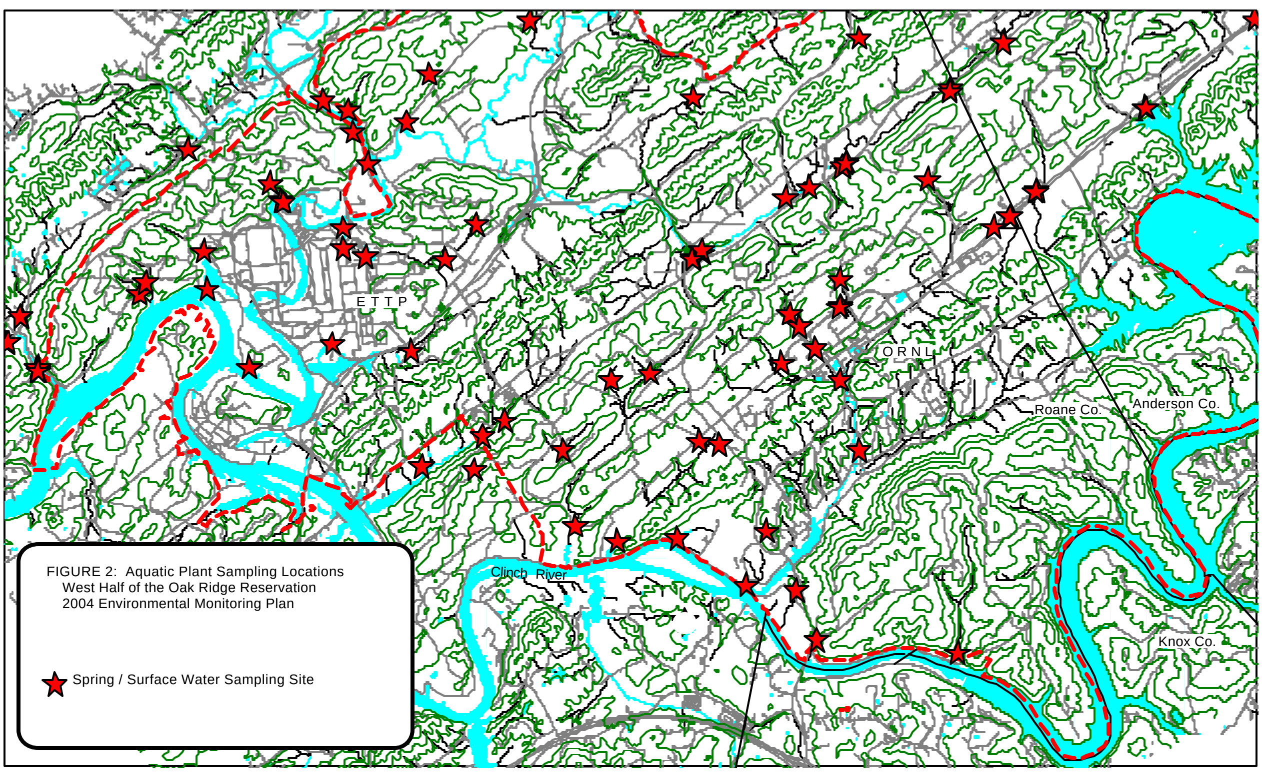


Figure 2: Potential Aquatic Plant Sampling Locations – West Half of ORR



The first two sampling seasons (2002-03) involved the sampling and analysis of watercress, algae, and aquatic vegetation. For 2004 the project broadened in scope to include determinations of the ecological implications of these findings. For 2005, the focus was returning to our highest hits from previous sampling to determine if a threat existed. Current data from sample results did not exceed action limits. Some sites are pending due to outstanding lab results. For 2006, a spring seep survey is planned near areas of concern in order to more closely evaluate potential hot spots. Samples will be taken at areas located.

Methods and Materials

Field samples will be collected at predetermined habitats and ecosystems both on the ORR and offsite (for background data). Plastic ziplock baggies and plastic (jar-like) containers will be used for collection of samples in the field. Rubber/plastic gloves will be worn during sampling activities. Each sampling location will be assigned an identification number (established spring names will be used for watercress samples) and mapped using global positioning system (GPS) technology. Rock substrate or Plexiglas plates will be used to sample the periphyton (diatoms).

Arrangements will be made in advance with appropriate Tennessee Oversight Agreement site coordinators for ingress/egress to radiological areas, to obtain Radiation Worker Permits, if necessary and for the presence of health physics technicians on an as needed basis. All samples will be screened radiologically in the field prior to returning to the division's office. Using radiological counting equipment available in the division laboratory, exposure rates (dose) will be calculated from selected field samples to determine exposure, absorbed dose, etc. Any Periphyton (diatoms) collected, will be identified using available TDEC microscopes and lab manuals (ORNL lab space & microscope equipment is available for taxonomy purposes upon request).

Samples collected will be shipped to the state Environmental Laboratory in Nashville for analysis of metals, gross alpha-beta and gross gamma parameters.

Target radionuclides being somewhat mobile and occurring in the ORR environment as contamination include (but are not limited to):

(1) Cesium-137
(2) Strontium-90
(3) Cobalt-60
(4) Uranium isotopes and daughter products
(5) Technetium-99

Metals of interest will include:

- Antimony
- Arsenic
- Beryllium
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Magnesium

- Mercury
- Nickel
- Selenium
- zinc

Sampling protocol and quality control methods will follow the guidelines in the division's "Standard Operating Procedures" and the "Health, Safety, and Security Plan." Field techniques and laboratory methods will follow standard ASTM, EPA, and FRMAC methodology, sampling, and operating procedures. Standard Operating Procedures for the project include (but not limited to):

(1) <u>ASTM Guidelines</u>:
ASTM Volume 11.02 – Organic Constituents/Radioactivity/Microbiological
ASTM Volume 11.05 – Biological Effects & Environmental Fate/Biotechnology
ASTM Volume 12.02 – Nuclear/Solar/Geothermal/Dosimetry/Radiation Effects

(2) <u>Federal Manual for Sample Processing and Analysis Manual (FRMAC) – 1996</u>:
   Vol. 1 – Radiation Monitoring & Sampling - Field Sampling: Vegetation/Fruit Sampling, Supplies and Procedure
   Vol. 2 - Sample Preparation and Analysis – Method 6: Preparation of FRMAC Field Samples
   Vol. 2 - Sample Preparation and Analysis – Method 7: Gamma Emitting Radionuclides in FRMAC Samples

(3) <u>U.S.G.S. Methods for Collection and Analysis of Aquatic Biological & Microbiological Samples: Book 5, Chapter A4</u>

(4) <u>U. S. Army Corps of Engineers: Wetlands Delineation Manual</u>

(5) <u>U. S. EPA Standard Operating Procedure – Ash Free Dry Basis – Periphyton</u>

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CHAPTER 3 DRINKING WATER

Sampling of Oak Ridge Reservation Potable Water Distribution Systems

Introduction

The water distribution systems at each of the DOE ORR sites are regulated by the *Tennessee Safe Drinking Water Act* (T. C. A. 68-13-701) and the *Regulations for Public Water Systems and Drinking Water Quality* (Chapter 1200-5-1). The Tennessee Department of Environment and Conservation Department of Energy Oversight Division (the division) may conduct oversight of sampling for total coliform bacteria and free chlorine residuals at various sites throughout the potable water distribution systems on the Oak Ridge Reservation (ORR). In addition, the division may oversee ORR line-flushing practices, water main repairs, cross-connection control programs, and water-loss/leak detection activities in order to identify potential threats to the potable water supply. If potential threats are identified, then additional chemical and radiological sampling may be conducted to insure that the quality of the potable water is maintained.

The division, through a memorandum of understanding (MOU) with the TDEC Division of Water Supply (DWS), reviews chemical and bacteriological sampling results from the drinking water distribution systems on the ORR. Review of these sampling results will be combined with:

- knowledge of localized plant populations and water demand
- backflow device location
- testing and maintenance procedures
- line repairs or maintenance
- proximity of water lines, identified on site maps, to radiological or non-radiological source waters will be used as a basis for TDEC DOE-O independent sampling when evidence exists of possible shallow subsurface plume infiltration, cross connections, low chlorine residuals, or other upset conditions.

Confirmation of any detects reported can dictate additional sampling or split samples. Continued detects may justify increased monitoring for that compound.

In addition, review of Cross Connection Control Programs will be conducted to evaluate the effectiveness of such plans and the degree of protection afforded by them. This will be checked by verifying inspection dates on backflow prevention (BFP) devices, review of records of BFP devices and inspection for possible unprotected cross connections.

Methods and Materials

The following sections provide information regarding the sample processing and analytical laboratory procedures.

Free Chlorine Residual

The sample will be collected into two of the small sample containers provided with the Hach Pocket Colorimeter Kit. One of the samples will be designated as the blank sample and the other will be the actual sample to be analyzed. A DPD powder pillow is poured into the sample container and gently shaken and allowed to sit for three minutes. After three minutes, the blank is placed into the pocket colorimeter and the “zero” button is depressed. The blank container is removed and replaced with the sample container. The "read" button is depressed and the free chlorine residual is read directly from the pocket colorimeter display.

Bacteriological

The U.S. Environmental Protection Agency (EPA) approved method for coliforms, Colilert in the pass/fail mode, will be the methodology utilized by the Tennessee Department of Health, Environmental Laboratory and Microbiology Laboratory Organization (Laboratory Services). For bacteriological testing on raw water sources, the counting application of the Colilert kits would be identified and utilized. The Lab has expertise in a broad scope of services and analysis available to the division and other TDEC divisions statewide.

Independent chlorine and bacteriological sampling will be conducted monthly at one of the three DOE facilities. Reasonable attempts will be made to rotate sampling between facilities each month. Specific sampling sites and number of samples will be determined based on water usage patterns, distribution system layouts, and other factors, such as construction activities and line breaks.

Organic, Inorganic and Radiological

Analytical methods are provided in the Standard Operating Procedures (SOP) manuals for the Tennessee Laboratory Services Division. The SOPs refers to proper EPA or other methods. In order to assess methods used division staff should communicate with their sampling and analytical counterparts within the ORR on a basis that facilitates technical exchange and openness. General sampling and analysis methods are to follow EPA guidelines as listed in appropriate parts of 40 Code of Federal Regulations (CFR).

Sampling of organic, inorganic, and radiological constituents will be conducted on an as needed basis when it has been determined that a possible threat to the quality of the drinking water exists.

Quality Control/Quality Assurance

If independent sampling activities are conducted, care will be taken to include quality control samples. The level of quality control methodology implemented will be commensurate with the level of independent sampling. Forms of control sampling to be considered will be blanks, duplicate analysis, division split samples, or even split samples with site DOE contractor. Information pertaining to the quality control samples will be included in program files, spreadsheets, and a bound notebook similar to actual samples.

Equipment that will be required to accomplish this oversight and sampling project:

- Latex gloves
- Hach Pocket Colorimeter Kit
- Hach free chlorine DPD powder pillows
- Bound field book
- State vehicle
- Health, Safety, and Security Plan
- Sample bottles
- Sampling cooler
- Disinfectant (full strength) spray bottle

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CHAPTER 3 DRINKING WATER

Implementation of EPA's Environmental Radiation Ambient Monitoring System (ERAMS) Drinking Water Program

Introduction

Radiological contaminants released on the Oak Ridge Reservation (ORR) enter local streams and are transported to the Clinch River. While monitoring of the river and local water treatment facilities has indicated concentrations of radioactive contaminants are below regulatory criteria, there remains a concern that ORR pollutants could impact area public water supplies. In response to these concerns, the Tennessee Department of Environment and Conservation Division of DOE Oversight (the division) began participation in EPA's Environmental Radiation Ambient Monitoring System (ERAMS) in 1996. This program provides for radiological monitoring of public water supplies near nuclear facilities throughout the United States. In this regard, the ERAMS program is designed to:

- Monitor pathways for significant population exposure from routine and/or accidental releases of radioactivity;
- Provide data indicating additional sampling needs or other actions required to ensure public health and environmental quality;
- Serve as a reference for data comparison (U.S. EPA, 1988)

The ERAMS program also provides a mechanism to evaluate the impact of DOE activities on water systems located in the vicinity of the Oak Ridge Reservation and verify DOE monitoring in accord with the *Tennessee Oversight Agreement* (TDEC, 2001).

Methods and Materials

As in the past, EPA will provide radiochemical analysis of finished drinking water samples collected quarterly by division staff at five public water supplies located on and in the vicinity of the ORR. This analysis will be performed at EPA's National Air and Radiation Environmental Laboratory in Montgomery, Alabama. ERAMS analytical frequencies and parameters are provided in Table 1.

Table 1: Environmental Radiation Ambient Monitoring System Analysis for Drinking Water

ANALYSIS	FREQUENCY
Tritium	Quarterly
Gross Alpha	Annually on composite samples
Gross Beta	Annually on composite samples
Gamma Scan	Annually on composite samples
Iodine-131	Annually on one individual sample/sampling site
Radium-226	Annually on samples with gross alpha >2 pCi/L
Radium-228	On samples with Radium-226 between 3-5 pCi/L
Strontium-90	Annually on composite samples
Plutonium-238, Plutonium-239, Plutonium-240	Annually on samples with gross alpha >2 pCi/L
Uranium-234, Uranium-235, Uranium-238	Annually on samples with gross alpha >2 pCi/L

The five Oak Ridge area monitoring locations are: Kingston Water Treatment Plant, Gallaher (K-25) Water Treatment Plant, West Knox Utility, city of Oak Ridge Water Treatment Facility (formerly the DOE Water Treatment Plant at Y-12), and Anderson County Utility District. Figure 1 depicts the approximate locations of raw water intakes associated with these facilities.

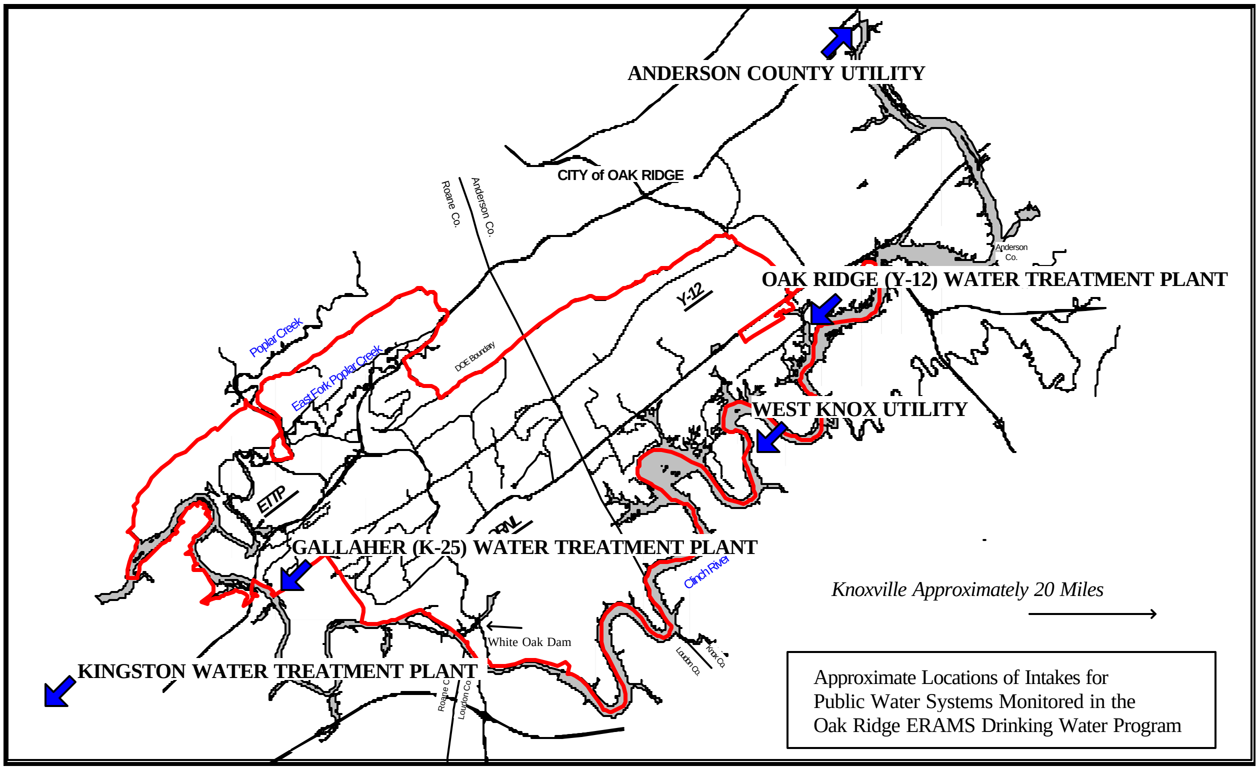

Figure 1: Approximate Locations of the Intakes for Public Water Systems Monitored in Association with EPA's Environmental Radiation Ambient Monitoring System (ERAMS) Drinking Water Program

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CHAPTER 4 GROUNDWATER MONITORING

2006 Oversight Groundwater Monitoring Plan for the Oak Ridge Reservation and its Environs

Introduction

In concordance with the mission of the State's Department of Energy - Oversight Office (DOE-O) as established under the Tennessee Oversight Agreement (TOA) and the (Federal Facility Agreement (FFA) to protect the people and environment of East Tennessee in respect of wastes and contaminant generated by Department of Energy operations, both legacy and current, the DOE-O conducts oversight monitoring of the groundwaters with the Oak Ridge Reservation and its Environs.

The primary goals of the DOE-Oversight Division's groundwater sampling program are:

- Perform surveillance to detect changes in groundwater quality at select locations and;
- Locate groundwater exit pathways;
- Locate groundwater impacts from past DOE Oak Ridge Reservation (ORR) operations both on-site and off-site.
- Integrate groundwater sampling with surfaced water sampling to produce a comprehensive monitoring report.

It should be emphasized that DOE-O groundwater monitoring is not intended nor are the resources allocated to be a Comprehensive and integrated monitoring program. Rather the division's Groundwater monitoring is designed in accordance with its oversight role to: perform as an assurance check on DOE groundwater monitoring quality, to monitor sites of specific interest to the state of Tennessee, and then to the extent possible to provide monitoring in gaps identified in the DOE groundwater monitoring program.

To the extent that gaps are identified in the DOE groundwater-monitoring program and the division performs monitoring, the purpose is not to replace DOE monitoring but to direct DOE and its extensive resources to areas of ground water concerns identified by the division.

Sites for groundwater monitoring to be performed by the division in 2006 can be divided into onsite and offsite locations. Onsite locations can be further subdivided by proximity or inclusion within the three main plant sites: Y-12, ETTP, and ORNL, it is further of use to divide the ORNL sampling into Bethel Valley containing the main campus and Melton Valley which entrains numerous legacy waste sites, non-operational experimental reactors and one operational reactor HFIR. A separate DOE facility known as South Campus or the Scarborough Facility is located in the former town of Scarborough at the East end of Bethel Valley. The South Campus is considered separately for division groundwater monitoring purposes.

A significant portion of the division's groundwater monitoring sites consists of springs and or seeps. In general the bedrock geology of the Oak Ridge Reservation can be divided between fracture flow systems within the clastic rocks of the reservation or fracture flow systems that have been dissolutionally enhanced within the soluble carbonate bedrock that also underlies the ORR. Groundwaters beneath the ORR eventually encounter fractures or dissolutionaly enhanced fractures (caves and conduits).which allows for the rapid transport of contaminated waters and discharges said waters in convergent locations generally manifested as springs and or seeps.

Sampling springs and seeps is essentially an exit pathway-monitoring program where hat also serves to allow effective monitoring with the minimal resources available for oversight activities.

Onsite Groundwater Monitoring:

Locations for and analysis performed for Onsite monitoring are determined in accordance with known or suspected process, legacy waste practices, concurrent and planned remedial activities, and with consideration of the known geologic and hydrologic framework of the ORR.

A general example of how analytes are chosen is demonstrated by the predominance of different radionuclides with the different sites. Thus Technetium 99 is part of general analysis for ETTP, Tritium for Melton Valley, and uranium for Y-12. Certain Isotopes such as Strontium 90 and the Uranium isotopes are indicated by general screening tests for the characteristic radioactive particles emitted. That is from prior knowledge the nuclide is presumed to be present and more expensive isotopic analysis is only employed when certain gross levels are exceeded. Generally spectrographic analysis for gamma emitting radiochemicals will be preformed on all radiologic samples collected.

In a similar vein analysis for metals and chlorinated solvents are performed on a site by site basis though analysis for these groups of contaminants is inherently of a more broad and general nature than much of the analysis for radiochemicals certain metals such as mercury require separate analysis and are generally only performed on the basis of site knowledge or occasionally on a new sampling location or location that is infrequently sampled as a field check on sampling decisions based on the division's knowledge of past and present DOE operations. Occasionally non-typical radiologic analysis is also performed under the same rubric as the non-typical metal analysis mention above.

Dye Tracing:

A subset of onsite groundwater monitoring will be the division's ongoing efforts to delineate groundwater basins or more simply put to understand where waters enter the groundwater systems on the reservation and where they exit the systems and what if any contaminants are acquired in the process. Tracer tests are performed using fluorescent dyes by injecting dye into the groundwater system generally either in a sinkhole or well and attempting to recover the dye or dyes at springs and or other wells. By establishing such locations, observing time and distances between input and extraction events for the dye or dyes - generalized pathways and flow rates for groundwaters can be observed and basins thus delineated.

Groundwater basin delineation is important to establish an understanding of fate and transport of contaminants within the ORR and to indicate proper locations for monitoring groundwater contamination or for predicting monitoring locations for maturing contaminant plumes. The division's activities regarding groundwater basin delineation will be dependant on the availability of personnel and resources.

In accordance with the above caveat the division would prioritize a dye trace from the southwest area of the SNS site on Chestnut Ridge which would be expected to flow toward the significant Maynardville Formation/Knox Group Springs located on the base of the escarpment of Chestnut Ridge and or toward the numerous smaller but not insignificant springs that originate in the Knox and generally form the headwaters of White Oak Creek.

General Dye Sampling:

In 2006 all groundwater sampling sites onsite and offsite will be monitored for fluorescent dyes as part of general analysis performed on sites. Analysis for dyes will be conducted for the purposes of establishing background for potential tracing studies and in recognition that fluorescent dyes are utilized at various times for various reasons within the main plants. Observation of fluorescent dyes in the division's groundwater sampling sites will allow identification of source locations should the original use of said dye be identified.

Offsite Sampling:

The division expects to maintain an active role performing oversight monitoring of groundwater in the environs of the Oak Ridge Reservation in calendar year 2006. Currently twelve sites located off the reservation were added to the division's groundwater monitoring program in 2005. These sites are expected to be monitored or potentially to be monitored in 2006. Sites sampled off the reservation consist of domestic wells or springs generally located on private property.

Location of these sites and sampling frequencies will be or have been established based on geohydrologic knowledge of the area, proximity to current and past DOE operations and by request in regards to access to privately owned wells and springs.

Sampling frequencies are also based on analytical results. For some domestic springs and wells sampling may only be conducted once every two years or even less frequently, if it is deemed to be a less than optimal location for monitoring any potential DOE impact to offsite groundwaters or if other nearby sites are considered to be providing adequate coverage of an area.

The 2006 plan calls for careful consideration and probable sampling of water wells located on the periphery of the ORR, if there is any potential for contaminants to affect the proposed site. More specifically division sampling efforts will be targeted to the areas located across the river and along geologic strike from Melton Valley and the historic K-25 site as these areas typically are served by domestic water wells and though it is considered unlikely masses of contaminants and the potential for mobilizing those contaminants does exist if in less than likely scenarios.

In its oversight role the division plans for its groundwater sampling offsite to act as a check and an assurance on the DOE's obligation to perform comprehensive and integrated offsite groundwater monitoring. This goal of a check and an assurance will however not be met in 2006 as there is no DOE offsite groundwater monitoring program to perform oversight on.

The division will, within the resources allocated to groundwater monitoring and within the scope of its mission, attempt to provide as much coverage of offsite groundwater as is feasible. It is expected in 2006 to add offsite locations as they become available either through requests received by the division from the public or by the division's initiative in contacting private well owners who have locations considered to meet the monitoring criteria cited above. To this end it is expected that it is possible that up to ten more sites may be added to the division's groundwater sampling routine.

Miscellaneous Groundwater Field Work:

- The inspection of wells;
- Locating new springs;
- Oversight of Underground Injection Control (UIC) wells and;
- Drilling of new wells or plugging of abandoned wells (P&A)

Methods and Materials

Sampling will generally be located along geologic strike and along cross strike geologic features, from the historically named Y-12, X-10, South Campus and the K-25 facilities. Water supply wells will be sampled by collecting water as close to the wellhead as possible. Water supply wells will be purged for at least 20 minutes or when seeing stabilization in field parameters. Monitoring wells will be co-sampled with facility personnel with few exceptions when disposable bailers might be used. Parameters, such as, pH, temperature, and conductivity will be collected before sampling and recorded on a sampling chain of custody sheets. Springs will be sampled based on field observation of flow and safety considerations.

Table 1 contains locations, analyses and sampling periods as described below. Specific radiochemical analyses will be determined prior to sampling or modified upon consultation with the Radiological Monitoring Oversight Program (RMO). Typically waters *a priori* influenced by K-25 would be analyzed for Tc-99. Water that may be influenced by X-10 will include (if gross beta results so warrant) Sr-90 analysis. If the gross alpha activity is greater than 5 pCi/L for domestic water supplies, then a radionuclide isotope specific analysis for alpha emitters will be performed on the laboratory-archived sample.

New sampling locations will include cation/anion parameters in order to calculate ionic charge balances. A list of metals that may include the health-based ones will be considered for analysis at new locations. Volatile organic compounds (VOCs) will be sampled for at all new springs. At sampling points where metals, VOCs or radionuclides indicate a need to determine their variability then appropriate samples will be taken.

The TDEC analytical laboratory in Knoxville, Tennessee will furnish sample containers. Samples will be collected using approved TDEC and EPA sampling procedures. Vinyl exam gloves and decontamination equipment and procedures will be necessary to avoid cross contamination. TDEC DOE-O sample coolers will be used to insure that samples are preserved in route to the laboratory. Appropriate lab, field and trip blanks will be utilized.

DOE Coordination/Communication

Upon selection of sampling points DOE will be notified by contacting the DOE Environmental Management Groundwater Program Manager, by e-mail and by letter. Ample notice will be given to DOE prior to sampling events to allow DOE the opportunity to observe or take split samples. Analytical results will be made available upon request.

All results and findings will be reported in the DOE-Oversight Division's Environmental Monitoring Report. It is anticipated there will be five sections in the 2005 Environmental Monitoring Report covering:

- Offsite Sampling Results (Private Residential and Non-community wells, and springs)
- Onsite Springs and Monitoring Wells
- Groundwater Tracing
- Chestnut Ridge Y-12 landfills
- Exit Pathway Investigations

Groundwater Tracing:

Individual traces will be documented with dye amounts, placement locations and monitoring locations with addenda (see Map 1 Basin Delineation). These addenda will contain the following:

- type of dye to be flushed
- amount of dye to be flushed
- location of dye placement point(s)
- location of monitoring points
- maps showing location in relation to active or inactive DOE facilities

The addenda will be distributed to those individuals at the facilities (Resource Management Organization, Laboratory or Plant Shift Superintendent), DOE contacts, UT-Battelle/Bechtel Jacobs/BWXT contacts and the division managers.

Groundwater dye tracing requires the availability of significant personnel resources, the ability of the division's Groundwater Monitoring Program to conduct groundwater basin deliniation will be dependant on the availability of personnel.

Table 1

Sampling and Analysis Matrix for 2006 Groundwater Program

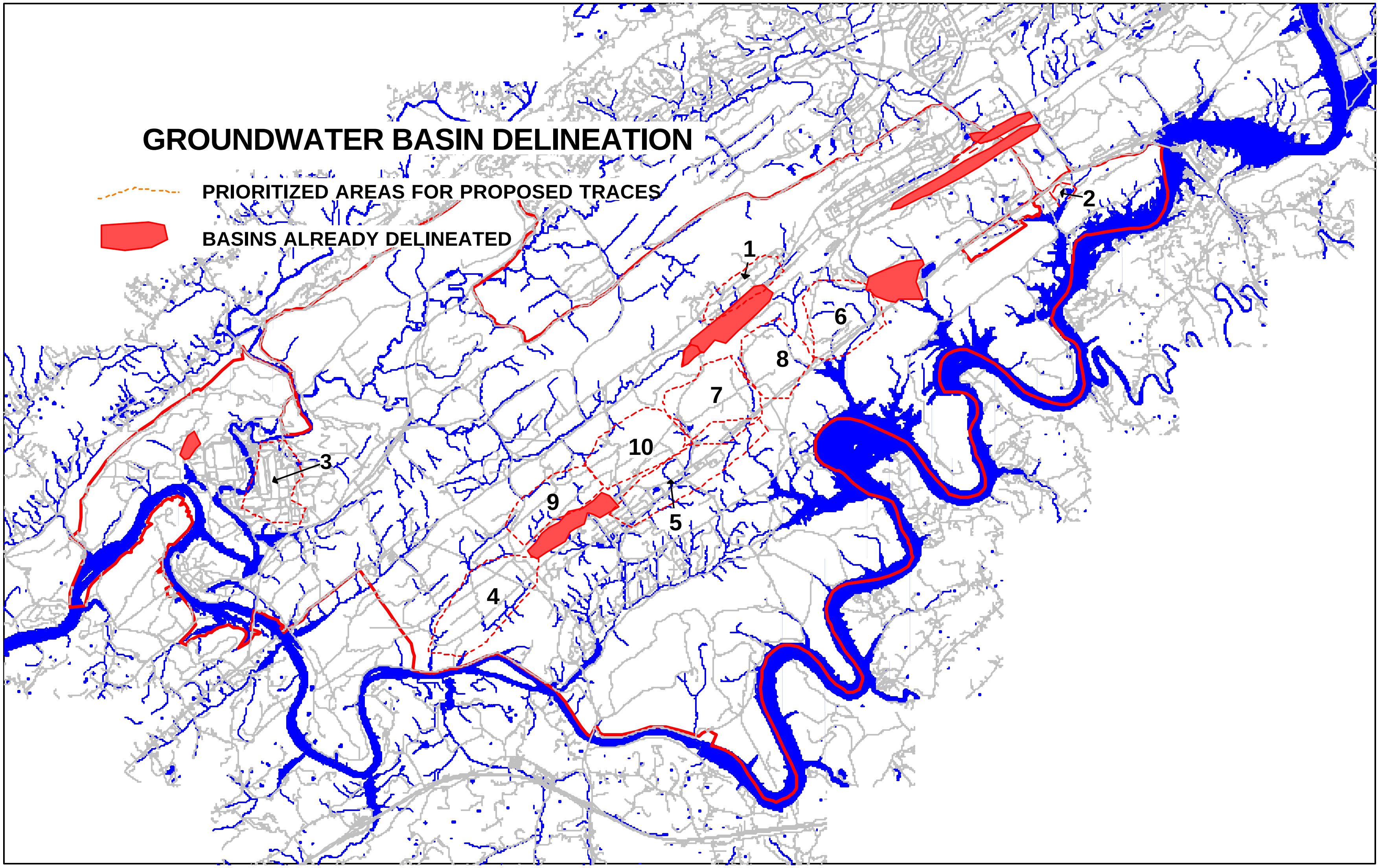
Area	**Quarters**				**Locations with sampling frequency other than quarterly, notes.**
	Q1	Q2	Q3	Q4	
Y-12 Landfills	Rad Met Inor Org Dye			Rad Met Inor Org dye	1. Mossy Rock Spring 2. Cephus Spring 3. Cabin Spring
EMWMF (sampling performed by RMO)	Rad Met Inor Org Dye		Rad Met Inor Org Dye		Covered by the Div Rad. Water Monitoring Program.
South Campus *Talk to Don*	VOCs Dye		VOCs Dye		1. Merak Spring 2. Co-Sample well TBD
Bear Creek	Rad VOCs Nut Dye	Rad VOCs Nut Dye	Rad VOCs Nut Dye	Rad VOCs Nut Dye	1. SS-8 Spring yearly 2. SS-7 Spring 3. SS-6 Spring 4. SS-5 Spring 5. New Weir - no VOCs 6. BC km-4.55 –no VOCs

Table 1 (continued)

K-25	VOCs Rad Dye	VOCs Rad Dye	VOCs Rad Dye	VOCs Rad Dye	1. Spring 10-895 monthly 2. PCO Seep 3. Syncline spring 4. Z-boil Spring 5. USGS 8-900
	Rad VOCs Dye	Rad VOCs Dye	Rad VOCs Dye	Rad VOCs Dye	6. Spring 21-002 7. Exit pathways on east bank of Clinch River TBD
SNS	Rad Dye		Rad Dye		1. SNS Spring 1 2. SNS Spring 3 3. SNS Spring 4 4. SNS Spring 6 5. SS-5 Spring 6. SS-6 Spring
Bethel Valley	Rad VOCs Dye		Rad VOCs Dye		1. Burns Cemetery 2. Raccoon Cr. Spring. 3. Gerry's Spring 4. Crooked Tree
Scarboro/ Union Valley	Rad VOCs Dye	RAD VOCs Dye	Rad VOCs Dye	RAD VOCs Dye	1. Cattail Spring monthly 2. Bootlegger Spring Monthly 3. Arboretum Wells
Melton Valley	RAD VOCs Dye		RAD VOCs Dye		1. Picket Wells TBD 2. Maynardville Spring?
Off-Site	Rad VOCs Met Dye	Rad VOCs Met Dye	Rad VOCs Met Dye	Rad VOCs Met Dye	2. 109 Weaver Road 3. Rose Bailey Lake Spring Wells 4. Love Spring 5. Dead Horse Spring TBD 6. Regina Loves Bobby Spring – monthly 7. RWA-22 8. RWA-65 9. RWA-56 TBD 10. RWA-74? 11. RWA-75 12. RWA-76 TBD

Table 1 (continued)

Tracing	Dye Dye	Dye Dye	Dye Dye Dye Dye	Dye Dye Dye Dye	EMWMF SNS South Campus East Tennessee Technology Park Raccoon Creek Area
Rad	= sample for radiochemicals: Gross Alpha, Gross Beta, Gamma Radionuclides, occasional Tritium and/or Technetium 99				
VOCs	= samples for Volatile Organic Compounds				
Nut	**=** samples for Nutrients (Nitrate – Nitrite)				
Met	**=** a sample that is analyzed for Arsenic, Beryllium, Cadmium, Chromium, Nickel, Lead, Selenium, Thallium, Vanadium, and Selenium. occasional Mercury				
Inor	= general inorganic parameters: Alkalinity as $CaCO_3$, Boron, Chloride, Conductivity, Nitrogen NO_3 & NO_2, pH, residue dissolves, residue, suspended, sulfate				



Map 1. Basin Delineation

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CHAPTER 4 GROUNDWATER MONITORING

Tracing Studies in the Y-12 Landfill area on Chestnut Ridge

Introduction

Since 2002, sampling of springs along the southeast facing slope of Chestnut Ridge to identify contaminant releases from landfills operated by the Y-12 Nuclear Weapons Facility has been incorporated into the division's groundwater monitoring program. Sampling carried out under both the plan to monitor springs down gradient from the landfills (before 2002) and under the DOE Oversight Division's groundwater monitoring program has not indicated the landfills are currently impacting water quality in the springs (TDEC, 1994-2003). However, elevated levels of suspended solids in springs have been observed after rainfall, apparently due to landfill operations and construction projects in the area.

The numerous small sinking streams and sinkholes along Chestnut Ridge must feed these springs, but the basins have not been delineated and the sources of the sediment load in the springs have not been clearly identified. Therefore, the emphasis of this monitoring project has shifted from spring sampling to tracing groundwater flow-paths on the southeast slope of Chestnut Ridge. The highest priority for tracing studies is up gradient of Spring 4.3 (Greenbarn Spring) and of a spring discharging just downstream of the weir at station 17 on the Kerr Hollow drainage (see Figure 1).

Methods and Materials

Tracing will be conducted using fluorescent dyes (Smart and Laidlaw, 1977). Analytical work will be performed on a field fluorometer and at a contract laboratory that provides spectrofluorophotometric analyses. Dye amounts will be estimated using published equations for computing mass of dye (Worthington and Smart, 2003). Work will be conducted in accordance with DOE Oversight procedures (Thomasson, 2005).

Coordination/Communication

Prior to commencing the trace, a registration of the work to be done will be filed with the Division of Water Supply and DOE will be notified by e-mail and by letter. Ample notice will be given to DOE prior to tracing to allow DOE the opportunity to observe or take split samples. Analytical results will be made available upon request. All results and findings will be reported in the DOE-Oversight Division's Environmental Monitoring Report. Traces will be documented with dye amounts, placement locations and monitoring locations.

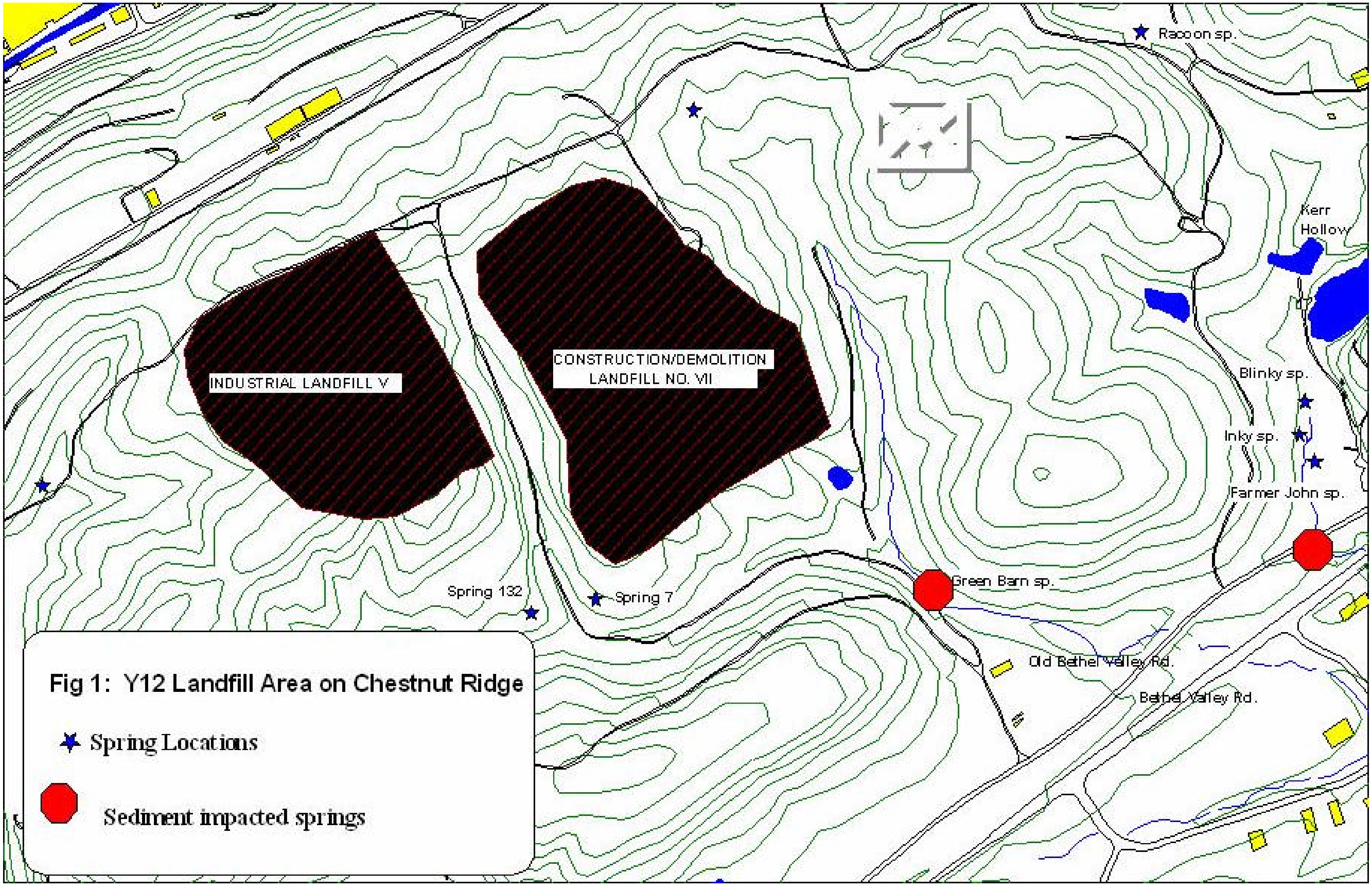

Fig 1: Y12 Landfill Area on Chestnut Ridge

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CHAPTER 5 RADIOLOGICAL MONITORING

Ambient Gamma Radiation Monitoring of the Uranium Hexafluoride (UF6) Cylinder Yards at the K-25 (East Tennessee Technology Park) Site

Introduction

During the development and operation of the gaseous diffusion uranium enrichment process, containers, support equipment, and support facilities were designed, constructed, and used to store, transport, and process the depleted UF_6. After a significant inventory was produced, outdoor storage facilities "cylinder yards" evolved. Today, DOE operates three K-25 (East Tennessee Technology Park) UF_6 cylinder storage yards. They are used for the temporary and long-term storage of UF_6 cylinders. The goal of the DOE-O UF_6 Cylinder Yard dose assessment program is to evaluate if the public is protected from radiation doses emitted from the cylinder yards. This is especially important since one DOE mission is to transform the East Tennessee Technology Park into a commercial industrial park.

Methods and Materials

Dosimeters measure the dose from exposure to gamma radiation over time. The division's cylinder yard monitoring is performed using Luxel® OSL (optically stimulated luminescence) dosimeters. They are obtained from Landauer, Inc., in Glenwood, Illinois. Optically stimulated luminescence dosimeters have an exposure range from 1 mrem to 1,000 rem for X and gamma radiation and are generally placed in areas where exposures are expected to be significantly higher than background. The dosimeters are collected quarterly by division staff and shipped to Landauer for processing. To account for exposures that may be received in transit or storage, control dosimeters are included in each shipment from the Landauer Company. The control dosimeters are stored at the division office and returned to Landauer with the associated 'in the field' deployed dosimeters for processing. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division office (761 Emory Valley Road, Oak Ridge, Tennessee), is subtracted from the exposure reported for the field deployed dosimeters. Annually, the quarterly exposures (minus the exposure obtained from the control dosimeter) are summed for each location. The resultant annual dose is compared to the state/DOE primary dose limit for members of the public (100-mrem/yr exposure). In addition to radiation dose measurements being gathered, dosimeter location data has been obtained using Global Positioning System (GPS) equipment. This data has been incorporated into a mapping information computer program. The location data that has been entered into the MapInfo program will be incorporated with past radiation dose measurement data so the user will have the ability to select a particular dosimeter and view its historical dose exposure measurement.

The project is slowly coming to a close due to the shipment of the UF6 cylinders to Portsmouth Ohio for final disposition. The state will continue to monitor the cylinder yards as they are cleared, and for at least one quarter after the yards are completely empty or as long as contamination is a concern.

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CHAPTER 5 RADIOLOGICAL MONITORING

Facility Survey Program and Infrastructure Reduction Activity

Project Description:

The Tennessee Department of Environment and Conservation's Department of Energy Oversight Division (DOE-O), in cooperation with the U.S. Department of Energy and its contractors, operates a facility survey program (FSP) on the Oak Ridge Reservation (ORR). The DOE-O survey program provides a comprehensive, independent characterization of facilities on the ORR based on their: operational history, present mission and physical condition, inventories of radiological and/or hazardous materials, degree of contamination, contaminant release history, and potential for release of contaminants to the environment.

Introduction

The Tennessee Department of Environment and Conservation's Department of Energy Oversight Division (DOE-O), in cooperation with the U.S. Department of Energy and its contractors, operates a facility survey program (FSP) on the Oak Ridge Reservation (ORR). The DOE-O survey program provides a comprehensive, independent characterization of facilities on the ORR based on their: operational history, present mission and physical condition, inventories of radiological and/or hazardous materials, degree of contamination, contaminant release history, and potential for release of contaminants to the environment.

The goal of the program is to fulfill part of the commitments agreed to by the state of Tennessee and the Department of Energy in Section 1.2.3 of the *Tennessee Oversight Agreement,* which states that "Tennessee will pursue the initiatives in attachments A, C, E, F, and G. The general intent of these action items is to continue Tennessee's: (1) environmental monitoring, oversight and environmental restoration programs; (2) emergency preparedness programs; and (3) delivery of a better understanding to the local governments and the public of past and present operations on the ORR and potential impacts on the human health and/or environment by the Oak Ridge Reservation." As part of this larger endeavor, *the facility survey program is designed to provide a detailed assessment of all potential hazards affecting or in any way associated with facilities on the Oak Ridge Reservation.* To meet this objective, survey team members walk through each facility and gather information that is recorded in a database that allows the team to characterize facilities and evaluate their potential for release of contaminants to the environment (PER). The conditions of facilities are considered within a variety of environmental conditions ranging from catastrophic (i.e. tornado, earthquake) to normal everyday working situations. From an emergency preparedness perspective such information is essential.

In 2002, the Department of Energy instituted a formal, accelerated D&D program aimed at facility reduction through demolition. Facility survey staff responded to this activity by making facility visits and walk-throughs of each facility prior to, and during demolition. Information concerning the nature, and destination of waste streams from the demolition sites is gathered and submitted to the division's Waste Management section. This activity will continue in 2006.

Methods and Materials

The criteria used in the selection of facilities to be surveyed include: 1) position of facility in S&M/D&D Programs; 2) perceived physical condition of facility; 3) perceived levels of contamination; 4) types or quantities of inventories (hazardous or radiological); and; 5) special circumstances (incidents, public or other agency request, or other unforeseen situations).

Using standard radiation survey instruments, inventory data, and historical documentation, staff walk through each facility and record information in a questionaire format. Based on these results and professional judgement, staff then rank the potential for release of contaminants to the environment (PER) for each facility by scoring 0 (least potential) to 5 (greatest potential) for each of 10 "categories." Tables 1 and 2 illustrate the scoring guidelines for potential environmental release, and the categories to be scored.

Table 1: Potential for Environmental Release Scoring Guidelines

Score	Score is based on observations in the field and the historic and present-day threat of contaminant release to the environment/building and/or ecological receptors.
0	No potential: no quantities of radiological or hazardous substances present.
1	Low potential: minimal quantities present, possibility of an insignificant release, very small probability of significant release, modern maintained containment.
2	Medium potential: radiological or hazardous subs. present, structures stable in the near to long term, structures have integrity but are not state-of-the-art, adequate maintenance.
3	Medium potential: structures unstable, in disrepair, containment failure clearly dependent on time, integrity bad, maintenance lacking, containment exists for the short term only.
4	High potential: radiological or hazardous subs. present. Containment for any period of time is questionable, migration to environment has not started.
5	Radiological or hazardous substance containment definitely breached, environmental/interior pollution from structures detected, radiological and/or hazardous substances in inappropriate places like sumps/drains/floors, release in progress, or radiological exposure rates above Nuclear Regulatory Commission (NRC) guidance.
Note: A score of 0 or 1 designates a low Potential Environmental Release rank; a score of 2 or 3 designates a moderate rank; a score of 4 or 5 designates a high rank.	

Table 2: Ten Categories Scored

1.	Sanitary lines, drains, septic systems
2.	Process tanks, lines, and pumps
3.	Liquid Low-level Waste tanks, lines, sumps, and pumps
4.	Floor drains and sumps
5.	Transferable radiological contamination
6.	Transferable hazardous materials contamination or waste
7.	Ventilation ducts and exit pathways to create outdoor air pollution
8.	Ventilation ducts and indoor air/building contamination threat
9.	Escalated radiation exposure rates inside the facility
10.	Escalated radiation exposure rates outside the facility

As facilities are surveyed, scored, and compared with each other, a relative "potential for environmental release" will emerge. The facilities that show a high potential for release of contaminants will be noted in the program's annual report. Staff will revisit these facilities at their discretion to evaluate changing conditions. Table 3 provides a list of target facilities to be surveyed during the next year.

Table 3: Target Schedule of Facilities to be Surveyed *

ORNL		Y-12		K-25	
Facility	**Date**	**Facility**	**Date**	**Facility**	**Date**
X-3550	Jan. 15	Y-9720-6	Jan. 15	On demand	
X-3030	Feb. 15	Y-1501-2	Feb. 15		
X-3031	Mar. 15	Y-9404-9	April 15		
X-3032	May 15	Y-9720-19	June 15		
X-3033	June 15	Y-9720-19A	Aug. 15		
X-3029	July 15	Y-9720-19B	Oct. 15		
X-3005	Sept. 15				
On demand		On demand			

* Facility numbers and dates are subject to change.

Appendices

None

References

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CHAPTER 5 RADIOLOGICAL MONITORING

Walkover Radiological Surveys

Introduction

The Tennessee Department of Environment and Conservation Department of Energy Oversight Division (the division) with the cooperation of the U.S. Department of Energy and its contractors conduct periodical radiological walkover surveys for the purpose of evaluating DOE property for re-use. Walkover surveys are done in conjunction with the CERCLA 120(h) process of establishing clean areas while following direct guidelines. In addition, walkover surveys may also be conducted on an as needed basis in conjunction with other special projects or on-going activities.

Background History of the Project

The Footprint Reduction Project focused on land parcels of the Reservation, considered not to be impacted by former DOE activities. This will continue on an as need basis.

Currently the project has incorporated the haul roads used by DOE for the transport of radiological waste. Reeves Road and Flannigan Loop Road are currently being monitored. Under a modified DOE Order 5400.5, any areas exceeding 200 dpm/100cm2 removable beta, 1000 dpm/100cm2 total beta, 20 dpm/100cm2 removable alpha, and 100 dpm/100cm2 total alpha would require remediation. These values are conservative based on the actual DOE Order 5400.5 for these contaminants. Of note, the Flannigan Loop Road area is high in shale, which is naturally higher in radioactive material. Additionally, portions of Lagoon Road are monitored where empty trucks are traversing, after dumping clean soil or materials off. This check is to insure they are not carrying contaminated mud from the site. A thorough beta-gamma scan is performed here as well.

Methods and Materials

The Walkover Surveys are conducted using a physical approach. Background material of the area is evaluated prior to a drive through of the area. From there, a walkover of the area is conducted with the use of a sodium iodide (gamma detector). Other radiological instruments are on hand as necessary. These include a beta-gamma pancake, a zinc scintillator for alpha, a micro-rem for tissue dose equivalence and a gamma spectroscopy for isotope identification. Areas with staining of soil or stressed vegetation are noted for sampling.

Staff conducts a thorough walkover of the area with the use of a global positioning system (GPS). Areas of concern, as well as other points, are logged to show coverage. A map of the area is printed out with points of interest or concerns plotted. A report is generated with the state's findings. Concerns are brought to the attention of the Federal Facility Agreement Project Managers for resolution.

References

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CHAPTER 5 RADIOLOGICAL MONITORING

Ambient Gamma Radiation Monitoring of the Oak Ridge Reservation Using Environmental Dosimetry

Introduction

Gamma radiation is emitted by various radionuclides that have been produced, stored, and disposed on the Oak Ridge Reservation (ORR). Associated radionuclides are evident in ORR facilities and surrounding soils, sediments, and waters. In order to assess the risk posed by these contaminants, the Tennessee Department of Environment and Conservation DOE Oversight Division (the division) began monitoring ambient gamma radiation levels on the ORR in 1995. The program is intended to provide:

- conservative estimates of the potential dose/risk to members of the public from exposure to gamma radiation attributable to DOE activities/facilities on the ORR;
- baseline values used to assess the need/effectiveness of remedial actions;
- information necessary to establish trends in gamma radiation emissions;
- information relative to the unplanned release of radioactive contaminants on the ORR.

In this effort, environmental dosimetry is used to measure the radiation dose attributable to external radiation at selected monitoring locations on and in the vicinity of the Oak Ridge Reservation.

Methods and Materials

Dosimeters used in the program will be obtained from Landauer, Inc., Glenwood, Illinois. Each of these dosimeters will use aluminum oxide photon detectors to measure the dose from gamma radiation (minimum reporting value = 1 mrem). At locations where there is a potential for the release of neutron radiation, the dosimeters will also contain an allyl diglycol carbonate based neutron detector (minimum reporting value = 10 mrem for thermal neutrons and 20 mrem for fast neutrons). Dosimeters that contain photon detectors alone will be collected quarterly and sent to Landauer for processing. Dosimeters that contain both photon and neutron detectors will be collected and processed semiannually.

To account for exposures that may be received in transit or storage, control dosimeters will be included in each batch of dosimeters received from the Landauer Company. These dosimeters will be stored in a lead container at the division office during the monitoring period and returned to Landauer with the associated field deployed dosimeters for processing. Any dose reported for the control dosimeters will then be subtracted from the dose reported for the field deployed dosimeters.[*] At the end of the year, the results will be summed for each location and the resultant annual dose compared to background values and the state/DOE primary dose limit for members of the public (100 mrem/year).

[*] *Note:* Prior to 2005, control dosimeters were stored unshielded at the division's offices during the monitoring period, which, in effect, incorporated background exposures for the monitoring interval into the control dose subtracted from the field dosimtry results. To comply with NRC guidance (Regulatory Guide 4.13) and associated protocol specified in ANSI N545-1975, staff began in 2005 to store the control dosimeters in a lead container during the monitoring period. Since the lead container shields the control dosimeter from background radiation, a background measurement is no longer included in the control dose or subtracted from the dose reported for the monitored sites. To evaluate the data, the doses from several background locations (areas that should be unaffected by DOE operations) are included in the data set (e.g., TDEC offices, Norris Dam, Fort Loudoun Dam).

Monitoring locations are chosen to identify sources of external radiation on the ORR, develop conservative estimates of the dose to the public from DOE operations/facilities, and collect information relative to the need and/or effectiveness of remediation. Candidate monitoring locations include: operating facilities; areas on the ORR that are accessible to the public; sites at the perimeter of the reservation near known radiation sources; local communities; and sites subject to or undergoing remediation. Locations currently monitored are provided in Table 1. Monitoring stations may be added or removed as conditions merit.

Table 1: Locations of Environmental Dosimeters Deployed on the Oak Ridge Reservation

Station Number (Dosimeter Type)	Location	Station Number (Dosimeter Type)	Location
9. (Photon)	Norris Dam Air Monitoring Station	48. (Photon)	Temp. 1: ETTP K-1420 Building
11. (Photon)	ETTP Grassy Creek Embayment on the Clinch River	51. (Neutron-Photon)	ETTP north side of the K-1066-E UF_6 Cylinder Storage Yard
12. (Neutron-Photon)	ETTP UF_6 Cylinder Yard K-1066-E	53. (Neutron-Photon)	ETTP southwest corner of the K-1066-K UF_6 Cylinder Storage Yard
15. (Photon)	ETTP K-1070-A Burial Ground	53a(Neutron/Photon)	ETTP southwest corner of the K-1066-K UF_6 Cylinder Yard (duplicate)
16. (Photon)	ETTP K-901 Pond	55. (Photon)	Temp. 8: ORNL SWSA 5 Tru Trench
17. (Neutron-Photon)	ETTP K-1066-K UF_6 Cylinder Yard	56. (Photon)	Temp. 9: ORNL Old Hydrofracture Pond
18. (Photon)	ETTP TSCA on fence across from Tank Farm	56a. (Neutron-Photon)	ORNL Old Hydrofracture Pond (duplicate)
20. (Photon)	ORNL Freels Bend Entrance	57. (Photon)	Temp. 10: ETTP UF6 Cylinder Storage Yard K-1066-B
21. (Photon)	ETTP White Wing Scrap Yard	61. (Photon)	Temp. 14: Outer & Illinois Ave
22. (Photon)	ORNL High Flux Isotope Reactor	62. (Photon)	Temp. 15: East Pawley
22a. (Photon)	ORNL High Flux Isotope Reactor (duplicate)	63. (Photon)	Temp. 16: Key Springs Road
23. (Photon)	ORNL Solid Waste Storage Area 5	64. (Photon)	Temp. 17: Cedar Hill Greenway
24. (Photon)	ORNL Building X-7819	65. (Photon)	Temp. 18: California Ave.
25. (Photon)	ORNL Molten Salt Reactor Experiment	66. (Photon)	Temp. 19: Emory Valley Greenway
26. (Photon)	ORNL Cesium Fields	67. (Photon)	Temp. 20: West Vanderbilt
27. (Photon)	ORNL White Oak Creek Weir @ Lagoon Rd	68. (Photon)	White Oak Creek @ Coffer Dam
28. (Photon)	ORNL White Oak Dam	69. (Photon)	ORNL Graphite Reactor
30. (Photon)	ORNL X-3513 Impoundment	70. (Photon)	Scarboro Perimeter Air Monitoring Sta.
31. (Photon)	ORNL @ Cesium Forest boundary	71. (Photon)	Y-12 East Perimeter Air Monitoring Sta.
31a. (Photon)	ORNL @ Cesium Forest boundary (duplicate)	72. (Photon)	ETTP Visitors Center
32. (Photon)	ORNL Cesium Forest on tree	73. (Photon)	Temp. 3: ORNL Spallation Neutron Source (north side)
33. (Photon)	ORNL Cesium Forest Satellite Plot	74. (Photon)	Temp. 4: ORNL Spallation Neutron Source (south side)
34. (Photon)	ORNL SWSA 6 on fence @ Highway 95	75. (Photon)	Temp. 5: ORNL hot spot on Haw Ridge
35. (Photon)	ORNL confluence of White Oak Creek & Melton Branch	78. (Photon)	Temp. 11: ED3 Quarry at Blair Road

Table 1: Locations of Environmental Dosimeters Deployed on the Oak Ridge Reservation Cont'd

38. Photon)	Y-12 Uranium Oxide Storage Vaults	79. (Photon)	Temp.12: ED1 on pole
39. (Photon)	Y-12 @ back side of Walk In Pits	80. (Photon)	Temp.13: Elza Gate
41. (Photon)	ORNL North Tank Farm	81. (Photon)	ORNL visitors center
42. (Photon)	ETTP east side of the K-1401 Building	86. (Photon)	Background at Ft. Loudoun Dam
43. (Photon)	ETTP west side of the K-1401 Building	86a. (Neutron-Photon)	Background at Ft. Loudoun Dam
44. (Photon)	ETTP K-25 Building	87. (Neutron-Photon)	ORNL SWSA 5
45. (Photon)	ETTP K-770 Scrap Yard	90. (Photon)	EMWMF
46. (Photon)	ORNL Homogeneous Reactor Experiment Site	91. (Photon)	Currently at TDEC DOE-O office
47. (Photon)	Y-12 Bear Creek Road ~ 2800 feet from Clinch River		

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CHAPTER 5 <u>RADIOLOGICAL MONITORING</u>

Real Time Ambient Gamma Monitoring of the Oak Ridge Reservation

Introduction

The Tennessee Department of Environment and Conservation DOE Oversight Division (the division) in association with its Ambient Gamma Radiation Monitoring Program has deployed continuously recording exposure rate monitors on the Oak Ridge Reservation since 1996. These instruments record gamma radiation levels at predetermined intervals for extended periods of time. The instruments have primarily been used to monitor remedial activities and supplement the integrated dose rates provided by environmental dosimeters. In this regard, the dosimeters provide a cumulative dose over the monitoring interval, but the data do not indicate the specific time and magnitude of fluctuations in the dose rates. Consequently, a series of small releases cannot be distinguished from a single large release using the dosimeters alone. In contrast, the exposure rate monitors provide a profile of gamma emissions that can be correlated with changing environmental and/or anthropogenic conditions.

Methods and Materials

The continuous exposure rate monitors that will be used in the program incorporate detection equipment, power supply, software, and associated instrumentation in a portable weather resistant case. The units are capable of measuring and recording gamma exposure rates from 1 µrem/hr to 1 rem/hr at predetermined intervals (one minute to two hours) over extended time periods (e.g., a year). The data can be downloaded in the field using an infrared transceiver, a lap top computer, and associated software.

Monitoring in the program will focus on the measurement of exposure rates under conditions where gamma emissions are expected to fluctuate substantially over short time periods or there is a potential for the release of gamma emitting radionuclides. The primary areas monitored in the program will be associated with remedial activities at locations where gamma radiation is known to be a concern. Monitoring stations can be expected to vary as the sites subject to remediation change and findings warrant. Sites currently monitored in the program include the Environmental Management Waste Management Facility (Y-12), the Y-12 Landfill (Y-12), the Molten Salt Reactor (Oak Ridge National Laboratory), and a background station (Fort Loudoun Dam). Additional candidates for monitoring in 2006 include the decommissioning and demolition of the K-25 and K-1420 facilities at East Tennessee Technology Park. Data collected from monitoring sites will be compared to the state limits for exposures to the public (2,000 µrem/hr) and the data collected at the background station.

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Thomassson, D.A., 2005. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

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CHAPTER 5 RADIOLOGICAL MONITORING

Surplus Material Verification

Introduction

The Tennessee Department of Environment and Conservation Department of Energy Oversight Division (the division), in cooperation with the U.S. Department of Energy and its contractors, conducts random radiological surveys of surplus materials that are destined for sale to the public on the Oak Ridge Reservation (ORR). In addition to performing the surveys, the division reviews the procedures used for release of materials under DOE radiological regulations. Also reviewed are any occurrence reports that involve surplus materials. Some materials, such as scrap metal, may be sold to the public under annual sales contracts, whereas other materials are staged at various sites around the ORR awaiting public auction/sale. The division as part of its larger radiological monitoring role on the reservation conducts these surveys to help ensure that no potentially contaminated materials reach the public. In the event that radiological activity is detected, the division will immediately report to the responsible supervisory personnel of the surplus sales program and follow their response to the notification to see that appropriate steps (removal of items from sale, resurveys, etc.) are taken to protect the public.

Methods and Materials

Staff members make random surveys of items that are arranged in sales lots by using standard survey instruments. Potential items range from furniture and computer equipment to vehicles and construction materials. Particular survey attention is paid to smaller equipment and parts. Where radiological release information is attached, radiation clearance information is compared to procedural requirements. If any contamination is detected during the on-site survey, the surplus materials manager for the facility will be notified immediately. In addition to radioactivity, any chemical concerns will be immediately brought to the attention of the manager.

References

Tennessee Department of Environment and Conservation. *Tennessee Oversight Agreement. Agreement between the U.S. Department of Energy and the state of Tennessee*. Oak Ridge, Tennessee. 2001.

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CHAPTER 6 <u>Surface Water Monitoring</u>

Monitoring of Liquid Effluents at the Environmental Management Waste Management Facility

Introduction

The Tennessee Oversight Agreement requires the state to provide monitoring as necessary to verify DOE data and assess the effectiveness of DOE contaminant control systems on the Oak Ridge Reservation (ORR). To this end, TDEC's Division of DOE Oversight proposes to monitor waste streams at DOE's Environmental Management Waste Management Facility (EMWMF), located in East Bear Creek Valley near the Y-12 National Security Complex. The EMWMF was constructed to dispose of waste generated by remedial activities on the ORR and is operated under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). While the facility is neither permitted nor regulated by state agencies, it is required to comply with substantive portions of legislation contained in the CERCLA Record of Decision (DOE, 1999) and requirements associated with responsibilities delegated to the DOE by the Atomic Energy Act.

While the availability of the EMWMF has expedited remedial activities, the water rich environment of the region has presented challenges to the containment of contaminants that would not be expected in more arid areas. For example, the height of the groundwater table, quantity of surface water runoff, and porosity of local soils were apparently underestimated in the planning stages, resulting in repairs and/or operational modifications to maintain control of contaminant releases. One such modification resulted in the excavation of french drain under the facility to lower the water table, which had risen to levels that approached the liner of the facility. Another modification requires the routine removal of liquids pooled over what should have been a porous layer emplaced to protect the leachate collection system and liner from being damaged during disposal operations. On at least two occasions, the pooling liquids have overflowed cell containment and discharged to the local environment. The liquid, a mixture of rainwater runoff and drainage from the waste, is now pumped to holding ponds, where it is sampled and then released to a ditch that empties into the sediment basin. The sediment basin discharges to a local tributary of Bear Creek (NT-5).

It is the intent of the project to verify effluents from the facility and associated contaminant control mechanisms are consistent with criteria agreed to by the state, EPA, and DOE.

Methods and Materials

Locations where sampling is currently planned are depicted in Figure 1. Descriptions of these sampling points are provided below.

- EMWMF 1: The background location (i.e. Catty Wampus Spring) located upslope of the facility at the headwaters of NT-4. The major portion of the NT-4 channel was filled and associated waters diverted to NT-5 to accommodate construction of the EMWMF.
- EMWMF 2: Discharges from the french drain emplaced under the facility to lower the groundwater table.
- EMWMF 3: The sediment basin at the outfall to NT-5.
- EMWMF 4: A surface drain for rainwater runoff.
- EMWMF 5: Drain where effluents from the ponds used to hold liquids that have accumulate over the protective layer are discharged.
- Other locations as merited.

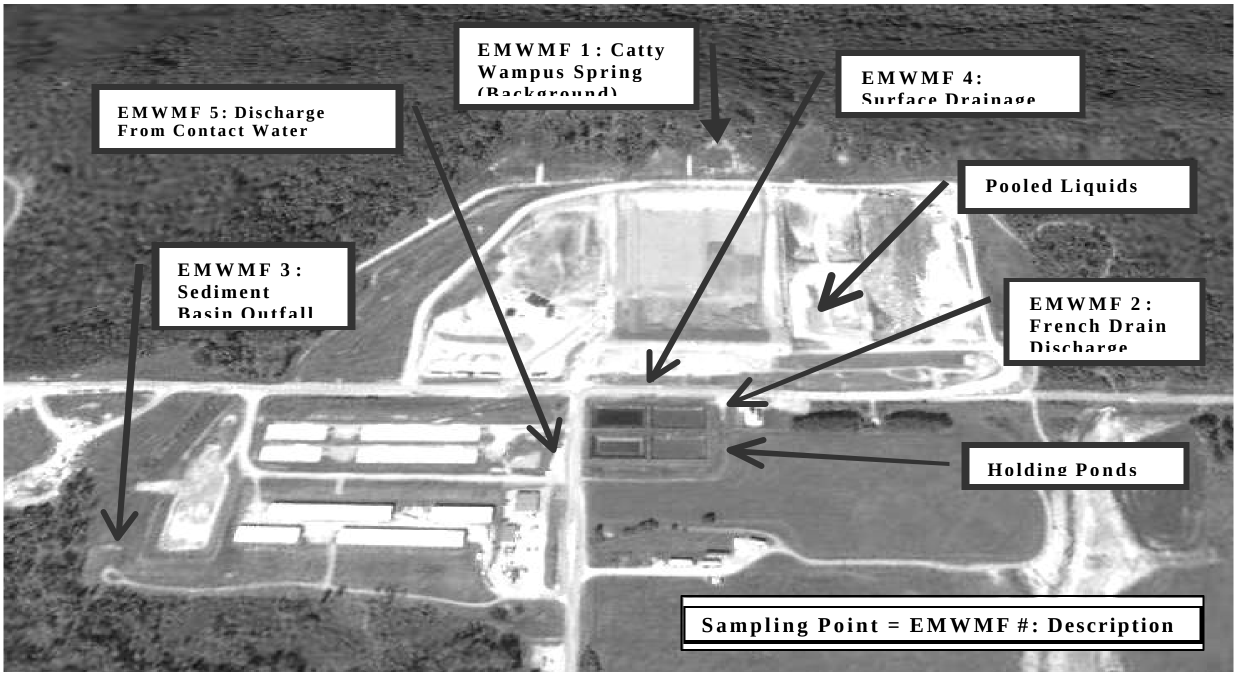

Figure 1: Sampling Locations at the Environmental Management Waste Management Facility

The media sampled is to include effluents, sediments, and biota. The analytical parameters are expected to evolve based on findings. At this point, numerous radionuclides have been disposed in the facility; each having different characteristics. For example, tritium and technitioum-99 would be expected to be more prevalent in liquids: whereas, heavy metals are generally associated with sediments. Since monitoring for all radionuclides disposed in the facility would be cost prohibitive, initial efforts will focus specific analysis on the more mobile species (e.g. tritium, technetium-99, carbon-14), containments previously detected in effluents (e.g. uranium isotopes, strontium-90, iodine-129), and radionuclides that would not be evident in gross measurements (e.g., tritium, carbon-14). Gamma spectrometry will be used to identify gamma emitters (e.g., cesium-137) and gross analysis will be used to screen for alpha and beta emitters, with more specific analysis performed in response to elevated results.

Sampling frequencies will depend on conditions and activities at the site. In general, concentrations of contaminants will fluctuate as site conditions change. The weather (precipitation), operational activities (pumping effluents from the holding ponds), and contaminants in the waste being disposed, each affect contaminant concentrations. Consequently, samples will be taken as conditions merit with the intent to monitor waste streams under different conditions in order to characterize and bound contaminant releases.

References

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CHAPTER 6 SURFACE WATER MONITORING

Rain Event Surface Water Monitoring

Introduction

Heavy rainfall events have the capability of transporting significant quantities of contaminants, which would normally remain in place, into nearby bodies of water. This mass transport can in turn impact the quality of the receiving waters. Due to the presence of areas of extensive point and non-point source contamination on the Oak Ridge Reservation (ORR), there exists the potential for contamination to impact surface waters on the ORR during excessive rain events. These events could cause the displacement of contamination that would not normally impact streams around the ORR.

To assess the degree of surface water impact caused by these rain events, a sampling of streams will be conducted following heavy rain events to determine the presence or absence of contaminants of concern. Table 1 shows locations that have been selected for sampling.

Table 1. Sample Locations

Site	Location
EFK 23.4	Station 17
WCK 3.0	White Oak Creek at Lagoon Road
MEK 0.1	Melton Branch Weir
MIK 0.1	Mitchell Branch Weir
BCK 4.5	Bear Creek Weir at Hwy. 95
MBK 1.6	Mill Branch (Reference)

Methods and Materials

In addition to temperature, pH, and conductivity, the following parameters will be analyzed for:
Inorganics: arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, zinc, nitrogen (NO_2 & NO_3), ammonia, nitrogen (total Kjeldahl), total phosphates.

Other tests: E. coli, Enterococcus, dissolved residue, suspended residue, and total hardness.

Radionuclides: Gross alpha, gross beta, gamma radionuclides.

Schedule

The monitoring will be conducted no more than once per quarter following either a 1" rain event in a 24-hour period or a 2" rain event over a 72-hour period.

Standard Operating Procedures

Special care must be taken when sampling water in which contaminants can be detected in the parts per billion and/or parts per trillion range. In order to prevent cross-contamination of these samples, the following precautions shall be taken when trace contaminants are of concern:

- A clean pair of new, non-powdered, disposable latex or vinyl gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come into contact with the media being sampled.

- Sample containers for source samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting, tagging, etc.

- If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples shall be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples shall never be placed in the same ice chest as environmental samples. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean, plastic bags.

- If possible, one member of the field sampling team should take all the notes, fill out tags, etc., while the other members collect the samples.

- When sampling surface waters, the water sample should always be collected before the sediment sample is collected.

- Sample collection activities should proceed progressively from the least suspected contaminated area to the most suspected contaminated area.

- Investigators should use equipment constructed of Teflon®, stainless steel, or glass that has been properly pre-cleaned for collection of samples for trace metals or organic compound analyses. Teflon® or glass is preferred for collecting samples where trace metals are of concern.

Sample Handling

After collection, all sample handling should be minimized. Investigators should use extreme care to ensure that samples are not contaminated. If samples are placed in an ice chest, investigators should ensure that melted ice can not cause the sample containers to become submerged, as this may result in sample cross-contamination. Plastic bags, such as Zip-Lock® bags or similar plastic bags sealed with tape, should be used when small sample containers (e.g., VOC vials or bacterial samples) are placed in ice chests to prevent cross-contamination.

Laboratory Procedures

The Tennessee Department of Health, Environmental Laboratory and Microbiological Laboratory Organization (Laboratory Services) has expertise in a broad scope of services and analysis available to the Tennessee Department of Environment and Conservation Department of Energy Oversight Division (the division) and other TDEC divisions statewide. General sampling and analysis methods are to follow Environmental Protection Agency (EPA) guidelines as listed in appropriate parts of 40 Code of Federal Regulations (CFR). Certain analyses and QC samples may be subcontracted out by Laboratory Services to independent laboratories. Bench level Quality Assurance/Quality Control (QA/QC) records and chain-of-custody records are maintained at the Tennessee Environmental Laboratory, as are QA records on subcontracted samples.

The division will use primarily the Knoxville Branch Laboratory Services. Wet chemistry and metals samples will generally be analyzed in Knoxville while organics samples will be sent on to the Central Laboratory in Nashville. All laboratory analysis will follow appropriate methods as documented in the Laboratory Services Inorganic Chemistry SOP and Organic Chemistry SOP. Specific analytical methods are covered in the Standard Operating Procedures (SOP) manuals for the Tennessee Laboratory Services Division. The SOPs direct analysts to the proper EPA or other methodology.

References

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CHAPTER 6 <u>SURFACE WATER MONITORING</u>

Ambient Sediment Monitoring Program

<u>Introduction</u>

Sediment samples are collected annually at sites on the Tennessee River, the Clinch River and some of its tributaries. The sediment samples are analyzed for organics, metals, and radiological contamination in order to assess the sediment quality for public health and ecological considerations. Sites 19, 21, 33, 34 and 35 were dropped from the program; results to date indicate no reason for concern. Sites 36, 37, and 38 are new sites added in the 2006 monitoring plan in order to assess and monitor the sediment quality in Poplar Creek.

The objective of this monitoring program is to assess the degree of sediment pollution of the Tennessee River, Clinch River and its tributaries.

Sample Locations

Site	Location	Clinch River Mile
2	Anderson County Water Treatment Plant	52.6
3	Downstream Williams Bend	35.5
4	Grubb Islands	17.9
5	Brashear's Island	10.1
6	Bull Run Steam Plant	48.7
7	City of Oak Ridge Water Treatment Plant	41.2
8	Scarboro Creek	41.2*
9	Kerr Hollow Branch	41.2*
10	McCoy Branch	37.5*
12	East Fork Walker Branch	33.2*
13	Bearden Creek	31.8*
17	Unnamed stream	20.0*
18	Raccoon Creek	19.5*
20	Grassy Creek	14.55*
22	Unnamed stream	14.45*
23	Ernie's Creek	51.1*
24	White Creek	102.4*
25	Clear Creek	78.2*
27	Clinch River	7.0
28	Clinch River	4.0
29	Clinch River Mouth	0.0
32	Clinch River Mile 19.7	19.7
33	Poplar Creek Mile 1.0	12.0
36	Poplar Creek Mile 2.2	12.0
37	Poplar Creek Mile 3.5	12.0
38	Poplar Creek Mile 5.5	12.0

*These samples will be collected at a point on the tributary upstream of the river far enough to get a sediment and water sample that would be characteristic of the tributary and not be affected by the high flow of the river.

Methods and Materials

Parameters to be analyzed

Inorganics: aluminum, arsenic, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, and zinc

Organics (extractables): butylbenzylphthalate, bis(2-ethylhexyl)phthalate, di-n-butylphthalate, di-n-octylphthalate, diethylphthalate, dimethylphthalate, n-nitrosodimethylamine, n-nitrosodiphenylamine, n-nitroso-di-n-propylamine, isophorone, nitrobenzene, 2,4-dinitrotoluene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, bis(2-chloroethyl) ether, bis(2-chloroethoxy)methane, bis(2-chloroisopropyl) ether, 4-bromophenylphenyl ether, 4-chlorophenylphenylether, hexachlorocyclopentadiene, hexachlorobutadiene, hexachlorobenzene, hexachloroethane, 1,2,4-trichlorobenzene, 2-chloronapthalene, 4-chloro-3-methyl phenol, 2-chlorophenol, 2,4-dichlorophenol, 2,4-dimethylphenol, 4,6-dinitro-o-cresol, 2-nitrophenol, 4-nitrophenol, pentachlorophenol, phenol, 2,4,6-trichlorophenol

Organics (pesticides/PCBs): aldrin, alpha-BHC, beta-BHC, delta-BHC, gamma-BHC (lindane), technical chlordane, alpha-chlordane, gamma-chlordane, 4,4-DDD, 4,4-DDE, 4,4-DDT, dieldrin, endosulfan I, endosulfan II, endosulfan sulfate, endrin, endrin aldehyde, endrin ketone, heptachlor, heptachlor epoxide, toxaphene, methoxychlor, PCB 1016/1242, PCB 1221, PCB 1232, PCB 1248, PCB 1254, PCB 1260, PCB 1262

Radiological: gross alpha (total), gross beta (total), gross gamma (total), *gamma radionuclides:* ^{137}Cs, ^{40}K, ^{214}Pb, ^{214}Bi, ^{212}Pb, ^{228}Ac, ^{208}Tl, ^{212}Bi and others as detected.

Schedule

The ambient sediment monitoring will be conducted in the second quarter of 2006.

Sediment Standard Operating Procedures

Sediment analysis is a key component of environmental quality and impact assessment for rivers, streams, lakes, and impoundments. Samples can be collected for a variety of chemical, physical, toxicological and biological investigations. This procedure is to be used to obtain quality assured sediment sampling. The resulting data may be qualitative or quantitative in nature and is appropriate for use in preliminary surveys as well as confirmatory sampling.

Required Equipment

sampling platform/boat	aluminum foil
depth finder	sample jars
stainless steel petite ponar grab sampler	sample labels
stainless steel mixing bowl	cooler/ice packs
stainless steel spoon	scrubber
pressurized water sprayer	lab sheets
deionized water	chain-of-custody forms
rubber gloves	field notebook

Procedure

If the water is wadeable, one can collect a sediment sample by scooping the sediment using a stainless steel spoon or scoop. This can be accomplished by wading into the stream, and while facing upstream, scooping the sample along the stream bottom in the upstream direction. If one is sampling a deep lake or impoundment, one can use the Petite Ponar dredge to obtain a sample. Step by step directions are as follows:

<u>Sediment sampling in wadeable streams and rivers</u>

1. Locate suitable sampling site. Remember that a site immediately downstream of a riffle area has the greatest amount of deposition since the velocity of the stream slows down. Beware of constrictions in the stream where scouring may be occurring.
2. Don rubber gloves to avoid self-contamination during sampling.
3. Using decontaminated stainless steel spoon, obtain sediment sample by scraping the streambed in the upstream direction.
4. Place three samples scoops in a stainless steel bowl and mix thoroughly to obtain a homogeneous sample.
5. Have sediment samples surveyed by Radiological Monitoring.
6. Carefully transfer sample into the appropriate containers as stated by the state of Tennessee Labs.
7. Record all pertinent information on lab sheets, sample labels, and make necessary entries into field notebook.
8. Place all samples into cooler as soon as possible. Temperature within the cooler should be maintained at 4 C by using ice or freezer packs.
9. Rinse all equipment using scrubber brush and sprayer filled with deionized water.
10. Deliver sediment samples to state lab within appropriate holding time frames, and sign chain-of-custody forms.

<u>Sediment sampling in lakes or reservoirs using Petite Ponar dredge</u>

1. Don rubber gloves to avoid self-contamination during sediment sampling.
2. Place stabilizing pin into arm attachments to lock dredge jaws in open position.
3. Using dredge cable, carefully lower dredge through water column. Slow the descent just prior to contact with sediment to prevent any disturbance to the sediment.
4. As the dredge contacts the sediment, allow the line to go slack, which in turn releases the stabilizing pin.
5. Give a quick tug to the cable; this enables the dredge jaws to close. Carefully pull the dredge through the water column.
6. Obtain three sediment samples this way and place each of them into a stainless steel bowl.
7. Using a stainless steel spoon, thoroughly mix the sediment to obtain a homogeneous composite.
8. Have sediment sample surveyed by Radiological Monitoring.
9. Carefully transfer the collected sediment into appropriate sampling jars as stated by the state of Tennessee Labs.
10. Record all pertinent information on lab sheets, samples labels, and make necessary entries into field notebook.

11. Place sediment samples into cooler as soon as possible. Temperature within the cooler should be maintained at 4 C by using ice or freezer packs.
12. Rinse all equipment using scrubber brush and sprayer filled with deionized water.
13. Deliver samples to state lab within appropriate time frames. Be sure to sign all chain-of-custody forms.

Laboratory Procedures

The Tennessee Department of Health, Environmental Laboratory and Microbiological Laboratory Organization (Laboratory Services) has expertise in a broad scope of services and analysis available to the Tennessee Department of Environment and Conservation (TDEC) Department of Energy Oversight (DOE-O) and other TDEC divisions statewide. General sampling and analysis methods are to follow Environmental Protection Agency (EPA) guidelines as listed in appropriate parts of 40 Code of Federal Regulations (CFR). Certain analyses and QC samples may be subcontracted out by Laboratory Services to independent laboratories. Bench level Quality Assurance/Quality Control (QA/QC) records and chain-of-custody records are maintained at the Tennessee Environmental Laboratory as are QA records on subcontracted samples.

DOE-O will primarily use the Knoxville branch of Laboratory Services. Wet chemistry and metals samples will generally be analyzed in Knoxville while organics samples will be sent on to the Central Laboratory in Nashville. All laboratory analysis will follow appropriate methods as documented in the Laboratory Services Inorganic Chemistry SOP and Organic Chemistry SOP. Specific analytical methods are covered in the Standard Operating Procedures (SOP) manuals for the Tennessee Laboratory Services Division. The SOPs direct analysts to the proper EPA or other methodology.

References

Martin Marietta Energy Systems, Inc. *Environmental Surveillance Procedures*. Oak Ridge, Tennessee. 1988. ESH/sub/87-21706/1.

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CHAPTER 6 SURFACE WATER MONITORING

Ambient Surface Water Monitoring Program

Introduction

Surface water sampling is conducted twice a year at 20 sites located on the Clinch River and it's tributaries. The surface water samples are analyzed for radiological activity, metals, nutrients and other parameters in order to assess the water quality for public health and ecological considerations. Sampling sites 1, 2, 24, and 25 are background data collection sites and are located upstream of the Oak Ridge Reservation (ORR). Sites 19, 21, 33, 34 and 35 were dropped from the program; results to date indicate no reason for concern. The other sites were chosen to detect contaminants being transported by surface water or stormwater coming from the ORR or areas affected by Department of Energy (DOE) related activities.

To assess the degree of surface water pollution of the Clinch River and its tributaries, the sites will be sampled semiannually. The water samples will be analyzed for certain inorganic (metallic and non-metallic) materials, environmental microbiological attributes, and some physical characteristics.

Sample Locations

Site	Location	Clinch River Mile
1	Downstream of Norris Dam, Clinch River	78.7
2	Anderson County Water Treatment Plant	52.6
3	Downstream of Williams Bend	35.5
4	Grubb Islands	17.9
5	Brashear's Island	10.1
6	Bull Run Steam Plant	48.7
7	Water Treatment Plant	41.2
8	Scarboro Creek	41.2*
9	Kerr Hollow Branch	41.2*
10	McCoy Branch	37.5*
12	East Fork Walker Branch	33.2*
13	Bearden Creek	31.8*
17	Unnamed Stream	20.0*
18	Raccoon Creek	19.5*
20	Grassy Creek	14.55*
22	Unnamed Stream	14.45*
23	Ernie's Creek	51.1*
24	White Creek	102.4*
25	Clear Creek	77.7*
32	Clinch River Mile 19.7	19.7

*These samples will be collected at a point on the tributary upstream of the river far enough to get a water sample that would be characteristic of the tributary and not be affected by the high flow of the river.

<u>Methods and Materials</u>
Parameters to be analyzed

Inorganics: arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, zinc, nitrogen (NO_2 & NO_3), ammonia, nitrogen (total Kjeldahl), total phosphorus.

Other tests: E. coli, Enterococcus, COD, dissolved residue, suspended residue, total hardness.

Schedule
The ambient water monitoring will be conducted in the second and fourth quarters.

Standard Operating Procedures
Special care must be taken when sampling water in which contaminants can be detected in the parts per billion and/or parts per trillion range. In order to prevent cross-contamination of these samples, the following precautions shall be taken when trace contaminants are of concern:

- A clean pair of new, non-powdered, disposable vinyl gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come into contact with the media being sampled.

- Sample containers for source samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting, tagging, etc.

- If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples shall be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples shall never be placed in the same ice chest as environmental samples. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean, plastic bags.

- If possible, one member of the field sampling team should take all the notes, fill out tags, etc., while the other members collect the samples.

- When sampling surface waters, the water sample should always be collected before the sediment sample is collected.

- Sample collection activities should proceed progressively from the least suspected contaminated area to the most suspected contaminated area.

- Investigators should use equipment constructed of Teflon®, stainless steel, or glass that has been properly precleaned (Appendix B) for collection of samples for trace metals or organic compounds analyses. Teflon® or glass is preferred for collecting samples where trace metals are of concern. Equipment constructed of plastic or PVC shall <u>not</u> be used to collect samples for trace organic compounds analyses.

Sample Handling

After collection, all sample handling should be minimized. Investigators should use extreme care to ensure that samples are not contaminated. If samples are placed in an ice chest, investigators should ensure that melted ice cannot cause the sample containers to become submerged, as this may result in sample cross-contamination. Plastic bags, such as Zip-Lock® bags or similar plastic bags sealed with tape, should be used when small sample containers (e.g., VOC vials or bacterial samples) are placed in ice chests to prevent cross-contamination.

Laboratory Procedures

The Tennessee Department of Health, Environmental Laboratory and Microbiological Laboratory Organization (Laboratory Services) has expertise in a broad scope of services and analysis available to the Tennessee Department of Environment and Conservation (TDEC) Department of Energy Oversight (DOE-O) and other TDEC divisions statewide. General sampling and analysis methods are to follow Environmental Protection Agency (EPA) guidelines as listed in appropriate parts of 40 Code of Federal Regulations (CFR). Certain analyses and QC samples may be subcontracted out by Laboratory Services to independent laboratories. Bench level Quality Assurance/Quality Control (QA/QC) records and chain-of-custody records are maintained at the Tennessee Environmental Laboratory, as are QA records on subcontracted samples.

DOE-O will primarily use the Knoxville branch of Laboratory Services. Wet chemistry and metals samples will generally be analyzed in Knoxville while organics samples will be sent on to the Central Laboratory in Nashville. All laboratory analysis will follow appropriate methods as documented in the Laboratory Services Inorganic Chemistry SOP and Organic Chemistry SOP. Specific analytical methods are covered in the Standard Operating Procedures (SOP) manuals for the Tennessee Laboratory Services Division. The SOPs direct analysts to the proper EPA or other methodology.

References

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CHAPTER 6 <u>SURFACE WATER MONITORING</u>

2006 Surface Water (Physical Parameters) Environmental Monitoring Plan

Introduction

Due to the presence of areas of extensive point and non-point source contamination on the Oak Ridge Reservation (ORR), there exists the potential for contamination to impact surface waters on the ORR. These events could cause the displacement of contamination that would not normally impact streams around the ORR.

To assess the degree of surface water impact relative to this potential contamination displacement, real time stream monitoring data will be collected weekly during 2006 from a site-wide network of primary ambient monitoring stations to establish a database of physical stream parameters (i.e., conductivity, pH, temperature, dissolved oxygen, etc.). Furthermore, this monitoring task is directed toward determining long-term water quality trends, assessing attainment of water quality standards and providing background data for evaluating stream recovery due to toxicity insults (stressors). Table 1 is a list of seven (7) field monitoring sites that have been selected for data collection.

Table 1. Sample Locations

Site	Location
EFK 23.4	Station 17
EFK 13.8	Oak Ridge Sewage Treatment Plant
BCK 4.5	Bear Creek Weir at Hwy. 95
BCK 9.6	Bear Creek Monitoring Location
BCK 12.3	Bear Creek Monitoring Location
MIK 0.1	Mitchell Branch Weir
MBK 1.6	Mill Branch (Reference)

Methods and Materials

Surface water physical parameters to be collected semiweekly at the seven sites include: dissolved oxygen (DO), pH, temperature and conductivity. The three watersheds to be monitored include: (1) two sites at Mitchell Branch watershed (East Tennessee Technology Park), (2) two sites at East Fork Poplar Creek watershed (Y-12 National Security Complex), and (3) three sites at Bear Creek watershed (Y-12 National Security Complex).

The monitoring and parameter data collection will (ideally) be conducted weekly at each of the monitoring stations (7 sites) listed in Table 1. It is estimated that approximately three hours per field trip will be required to collect data at all seven monitoring sites.

The instrument to be used for the project is the Horiba U-10™ Water Quality Checker (LCD readout). This state-of-the-art hand-held instrument is used for simultaneous multi-parameter measurement of water quality and measures the following: pH, conductivity, turbidity, dissolved oxygen, temperature, and salinity. The instrument consists of a probe unit (with various sensors) attached to a handheld unit (LCD readout & keypad) via a 3-foot cable. Measurements are taken simply by immersing the probe directly into the creek, pond, or river, and parameter readings can then be recorded from the hand-held unit LCD readout (one parameter at a time is displayed and is initialized using the keypad).

In the event real-time field readings such as pH and conductivity are beyond benchmark ranges, then the following action will be taken: (1) wait 24 hours, re-calibrate Horiba™ instrument, and re-take physical parameter readings; (2) if readings are still deviant, investigate possible causes (e.g., defective equipment, storm surge/rain events, releases that may have affected pH, etc.); (3) following investigation, report findings to appropriate program(s) within the division to determine further action, if needed.

Standard Operating Procedures

Special care must be taken when monitoring water in which contaminants can be detected in the parts per billion and/or parts per trillion range. Also, proper maintenance and care of the Horiba U-10™ instrument is essential. The instrument should be recalibrated regularly. In order to prevent or minimize cross-contamination and to extend the life of the monitoring instrument, the following precautions are recommended as QA/QC procedures:

- The Horiba U-10™ instrument should be recalibrated prior to going to field each week, and this data logged into the laboratory notebook.
- After instrument readings have been recorded at each monitoring station, the instrument probe should be rinsed and cleaned with deionized water (three times) before being used at the next monitoring site.
- The instrument probe parts should be thoroughly rinsed and cleaned prior to storage (after returning from each field outing). The Horiba U-10™ owners manual specifies that the pH sensor must always be kept moist during long term storage; also, remove the battery from the main unit prior to long term storage.
- If possible, one member of the field sampling team should take all the notes, fill out forms, etc., while the other member collects the field data using the Horiba U-10™ instrument.
- Sample collection activities should proceed progressively from the least suspected contaminated area to the most suspected contaminated area.

Sample Handling

No water quality samples will be collected during this project.

References

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CHAPTER 6 SURFACE WATER MONITORING

Underwater Survey

Introduction

Historical operations at the East Tennessee Technology Park may have resulted in the disposal of used equipment and materials into Poplar Creek and the Clinch River. Although no firm documentation exists to support this, there is extensive anecdotal evidence and personal communication to warrant a survey of these two bodies of water to identify possible contaminated material. New technology now allows the use of relatively inexpensive equipment, side scan sonar, to be used to possibly identify underwater structures.

In addition to the presence of point sources resulting from historical disposals, DOE activities on the ORR have resulted in radiological discharges to the Clinch River. Although these discharges are not the sole reason for the extirpation of most mussel species from the Clinch River, they were a contributing factor.

Methods and Materials

Using a side scanning sonar mounted on a boat, 100 meter longitudinal transects will be made in the near shore areas of Poplar Creek and the Clinch River. These transects will be made such that they follow bottom contours as closely as possible (USACOE, 2004). The number of adjacent transects required will be dependent on the capabilities of the sonar unit that is utilized. Regardless, transects will be placed such that there will be at least a 20% overlap of coverage between adjacent transects. When an underwater structure is identified on the sonar, GPS coordinates will be recorded to mark the location. A description will be made of the area and further investigation will be conducted to determine if the structure is man made and if so, the source of the structure. If possible, water and sediment samples will also be taken from the immediate area to determine if the structure is contributing contaminants to the environment.

During the survey of the Clinch River, attempts will be made to identify areas that would be likely mussel beds. If likely areas are identified, then arrangements will be made to collect mussel relics from the area. Since the mussel populations in the Clinch River have been almost completely extirpated, the collections will consist primarily of sampling for relics. This will involve the use of divers to make the collections. In addition, the remote possibility that federally endangered species may be present will require the presence of an experienced malocologist. The presence of these endangered species precludes the use of remote sampling equipment.

Collected relics will be analyzed for gross alpha, gross beta, gamma radionuclides, and Sr-90.

References

American Society for Testing and Materials. *Standard Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing*, E 1391-90, American Society for Testing and Materials, Philadelphia, PA, 1990.

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CHAPTER 6 SURFACE WATER MONITORING

Contaminated Groundwater Discharges from the ORNL 7000 Area into White Oak Creek

Introduction

Recent sampling in White Oak Creek (WOC) and its tributaries has confirmed that volatile organic compounds (VOCs) are migrating from the 7000 area at ORNL to the creek (Bechtel Jacobs Corporation, 2005). This sampling was conducted using transects every 200 feet, and could not be used to locate all suspected discharge points for contaminated groundwater. The sampling did implicate one tributary spring and a creek reach of less than 750 feet as being the major discharges of groundwater contaminated with VOCs. Since more than one source of VOCs is likely to be present in the ORNL 7000 area, further investigation of the discharge points of contaminated groundwater is warranted to support monitoring of any actions toward groundwater remediation in the 7000 area.

The objective of this project is to further delineate discrete discharges of contaminated groundwater along the reach of WOC identified by Bechtel Jacobs Corporation (2005) by transect sampling of the stream for VOCs at intervals of 50 to 100 feet. Tributary streams, drains or springs that act as in-feeders to the creek along the reach may also be sampled. Discharge will be measured or estimated at each location so the VOC flux in surface water can be determined along the stream. It is anticipated that about 15 samples (including at least one QA sample) will be collected and analyzed for VOCs on each of two sampling events. Sampling will be conducted initially for screening, both to better identify any discrete discharge points such as seeps or drains and to determine stream reaches having no apparent influx of contaminated water. After reviewing data from the first sampling event, re-sampling will be carried out to better define the contribution of any discrete groundwater or surface water discharges into WOC.

Schedule

Inasmuch as is possible, the monitoring will be conducted at a time when streams are at low flow, but temperatures are cool. This should maximize the influence of springs and seeps on water chemistry while minimizing loss of volatiles from the creek to the atmosphere.

Standard Operating Procedures

Special care must be taken when sampling water in which contaminants can be detected in the parts per billion and/or parts per trillion range. In order to prevent cross-contamination of these samples, the following precautions shall be taken:

- A clean pair of new, non-powdered, disposable latex or vinyl gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come into contact with the media being sampled.

- Sample containers for source samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting, tagging, etc.

- Samples of waste or highly contaminated samples shall never be placed in the same ice chest as environmental samples. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean, plastic bags.

- If possible, one member of the field sampling team should take all the notes, fill out tags, etc., while the other members collect the samples.

- Sample collection activities should proceed progressively from the least suspected contaminated area to the most suspected contaminated area.

- Investigators should use equipment constructed of Teflon®, stainless steel, or glass that has been properly pre-cleaned for collection of samples for trace metals or organic compound analyses. Teflon® or glass is preferred for collecting samples where trace metals are of concern.

Sample Handling

After collection, all sample handling should be minimized. Investigators should use extreme care to ensure that samples are not contaminated. If samples are placed in an ice chest, investigators should ensure that melted ice does not cause the sample containers to become submerged, as this may result in sample cross-contamination. Plastic bags, such as Zip-Lock® bags or similar plastic bags sealed with tape, should be used when small sample containers (e.g., VOC vials or bacterial samples) are placed in ice chests to prevent cross-contamination.

Laboratory Procedures

The Tennessee Department of Health, Environmental Laboratory and Microbiological Laboratory Organization (Laboratory Services) has expertise in a broad scope of services and analysis available to the Tennessee Department of Environment and Conservation Department of Energy Oversight Division (the division) and other TDEC divisions statewide. General sampling and analysis methods are to follow Environmental Protection Agency (EPA) guidelines as listed in appropriate parts of 40 Code of Federal Regulations (CFR). Certain analyses and QC samples may be subcontracted out by Laboratory Services to independent laboratories. Bench level Quality Assurance/Quality Control (QA/QC) records and chain-of-custody records are maintained at the Tennessee Environmental Laboratory, as are QA records on subcontracted samples. All laboratory analysis will follow appropriate methods as documented in the Laboratory Services Organic Chemistry SOP. Specific analytical methods are covered in the Standard Operating Procedures (SOP) manuals for the Tennessee Laboratory Services Division. The SOPs direct analysts to the proper EPA or other methodology.

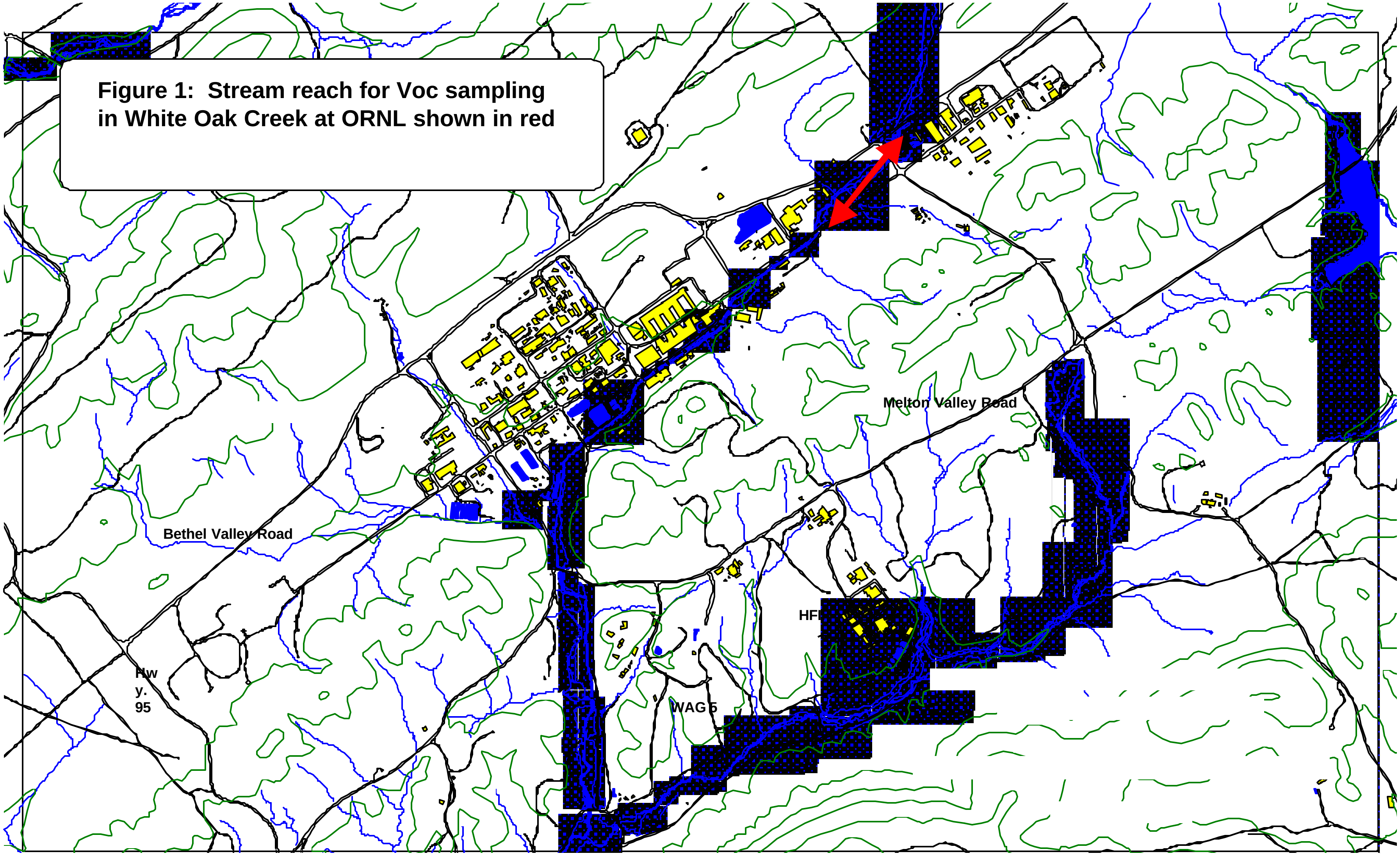

Figure 1: Stream reach for Voc sampling
in White Oak Creek at ORNL shown in red
Melton Valley Road
Bethel Valley Road
Hw
y.
95
HF
WAG 5

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